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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, 1939

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE,
Washington, D. C., September 13, 1939.

HON. HENRY A. WALLACE,
Secretary of Agriculture.

DEAR MR. SECRETARY: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1939.

Sincerely yours,

LEE A. STRONG, *Chief.*

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INTRODUCTION

The organization of the Bureau activities remains practically unchanged. The eradication and control of plant pests have been continued under a program expanded by allocations of emergency relief funds. There has been a curtailment in these operations as a result of reduced allotments.

As the result of extensive experiments to determine the possibility of so treating fruit originating in countries in which fruitflies are known to occur as to insure that it be free from infestation, fruit from certain fruitfly-infested areas has been admitted subject to sterilization by the time-temperature method. This method of treatment during the year was extended to cover the shipment of certain fruits and vegetables from Hawaii to the mainland.

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For the last 2 or 3 years the infestation of the pink bollworm in the lower Rio Grande Valley of Texas and across the international boundary in Mexico has been the cause of considerable concern because of the danger of spread into and through the main Cotton Belt. The efforts to suppress this infestation have attracted considerable attention, the most recent manifestation of which is Federal legislation approved August 9, 1939, authorizing conversations between representatives of the United States and Mexico to consider eradicating or controlling the pink bollworm in both countries by a cooperative program.

PUBLICATIONS AND EDITORIAL WORK

During the year 503 manuscripts were presented for publication and 488 were approved, 98 being submitted to the Department for publication and the remaining 390 to outside journals. There remained on hand 168 manuscripts, 130 of which were under consideration in the Bureau, 18 were in the Office of Information awaiting publication by the Department, and the remaining 20 were in press at the Government Printing Office. Of the 130 in the Bureau, 76 were being considered for publication by the Department and the remaining 54 for publication in outside periodicals.

LIBRARY

The use of the Bureau library showed an increase of over 13 percent in the loan and reference work this year.

Several special bibliographies were prepared, among them those on the effect of X-rays on insects, on the effect of infrared rays on insects, on the effect of ultraviolet rays on insect life, and on insect tropisms. The Index to American Economic Entomology and the special indexes in the Bureau library have been brought up to date, and Entomology Current Literature has been issued bimonthly.

A number of very desirable exchanges have been effected through the Barnes collection, and many additions have been made to the collection of photographs of entomologists.

INSECT PEST SURVEY AND INFORMATION

The Survey added to the permanent files on the distribution and abundance of insects 25,100 notes on domestic insects and 11,500 notes on foreign insects, bringing the total now available for consultation to 315,250. There were added 800 species of insects to the existing record of approximately 20,000 species of American insect pests, and the foreign-pest file now contains over 22,000 species. To the host-plant file there were added 25 new genera and 165 new species, bringing the totals to 1,125 genera and 2,600 species.

The monthly Insect Pest Survey Bulletin was augmented by supplements on Alfalfa Weevil Spread in 1938; Alfalfa Weevil Survey, Fall of 1937; Relative Abundance of the European Corn Borer in 1938; Distribution and Colonization of European Corn Borer Parasites in 1938; The Field Status of Parasites of the European Corn Borer in the Fall of 1937; Grasshoppers, Species and Distribution in the 1937 Outbreak; Hessian Fly Survey at Harvest Time, 1938; June Beetles,

Population and Host Preferences in Southern Wisconsin in 1935, 1936, and 1937; and Notes on Tobacco Insects in 1937.

Sixty-nine articles on entomological and quarantine subjects were released to the press, and 68 radio talks were put on the air. Preparation of film-strip material covered 7 new subjects. Two new motion pictures were completed, one on grasshoppers and the other on the Mormon cricket. Both are sound pictures. The Bureau participated in 10 exhibits. One of these, comprising material on barberry eradication, the white-fringed beetle, the European corn borer, the Dutch elm disease, the Japanese beetle, and grasshoppers, was installed in the rotunda of the State Capitol at Jefferson City, Mo., from March 27 through June 2. The attendance during which this material was on exhibit totaled over 66,000.

Cooperative extension work in entomology was supervised under the direction of the Bureau and the Office of Cooperative Extension Work.

Twelve numbers of the Bureau Monthly News Letter were issued, comprising a total of 353 pages. In addition to those sent out on regular mailing lists and miscellaneous mimeographed material, 338,850 copies of publications were distributed.

During the year 2,615 orders for duplicating and photographic material were placed for 1,452,296 copies in all. Of these orders 618 were for photographic work in the Bureau's laboratory, calling for 9,980 prints and negatives. The duplicating work included general Bureau mimeographing, quarantine and administrative instructions, and B. E. P. Q. circulars. Thirty-three mailing lists were maintained in this division.

To the file of photographic prints under the custody of this division there have been added 1,250 new subjects. A total of 1,339 prints have been distributed, on special request, to scientific workers, magazine editors, writers, students, teachers, and others.

FRUIT INSECT INVESTIGATIONS

APPLE AND PEAR INSECTS

Tank-mixed nicotine-bentonite has continued to give very satisfactory control of the codling moth under conditions of severe infestation in southern Indiana. During 1938 this material was used successfully by several Indiana growers throughout most of the season on at least 700 acres. The need for the development of fungicides that will be compatible with nicotine-bentonite and not reduce its efficiency has been further emphasized. Some of the newer copper fungicides have been tested, but either they have interfered with the effectiveness of the nicotine-bentonite in codling moth control, or the combinations have caused serious foliage injury. In other areas the control obtained by the use of the tank-mix nicotine-bentonite has been rather satisfactory except that in some instances the residues have been objectionable and difficult to remove.

Phenothiazine was tested further in southern Indiana, in the Pacific Northwest, and in the Hudson River Valley. For the most part the results were very poor. The reasons for this lack of effectiveness have not been determined. Phenothiazine was found very effective in preventing secondary scab infestation, according to counts made in the Indiana plots by representatives of the Bureau of Plant Industry.

Studies of the influence of particle size, carried on at the Beltsville, Md., laboratory, have indicated that extreme fineness is not necessary for the maximum effectiveness of lead arsenate, calcium arsenate, cryolite, paris green, or phenothiazine in the control of the codling moth. On the other hand, an extremely coarse sample of phenothiazine was much less effective than the materials having either a fine or medium average particle size.

The large-scale field tests of baits carried on at Yakima, Wash., in 10 acres of orchard resulted in the capture of more than 144,000 moths; yet there was very little difference in favor of the baited area in terms of worm injury to fruit at harvest time. Studies carried on in the baited block by means of the release of marked moths indicated that 50 percent of them were being captured in the baits. The removal of this large number of moths from the block must have reduced the moth population materially, and it is believed that the failure to show a benefit was the result of movement of moths from nearby unbaited areas into the experimental block. At Vincennes, Ind., where the results of large-scale baiting tests were somewhat similar, studies of moth movement by means of releases of marked moths and their subsequent recapture in traps showed definitely that a heavy movement of moths into the baited area took place during the summer.

The mechanical-biological project in West Virginia to control the codling moth was continued. The experimental orchard bore a heavy crop of fruit in contrast to last year's very light yield. The proportion of fruit injured by the codling moth dropped from 72 percent in 1937 to 63 in 1938, this being largely the result of the increased number of apples available for worm attack. The percentage of parasitization remained practically the same, whereas the percentage of larvae killed by predators increased from 10.5 percent in 1937 to 12.6 in 1938. Studies of codling moth predators were conducted also at the St. Joseph, Mo., laboratory.

Phenothiazine continued to give control of the apple maggot in the Hudson River Valley, when used either throughout the season or as a final spray following a light program of arsenical applications. Ground cube root failed to reduce apple maggot infestation to any extent, even though five applications were made. Commercial nicotine-bentonite also failed to control the apple maggot in an orchard receiving five applications during the period of adult abundance.

In studies of the common red spider on apple in the Missouri River Valley, data were secured confirming results obtained in 1936 and 1937, viz, that the thorough application of sulfur materials in the calyx and first cover sprays effects a marked reduction in populations, which appears to delay the spider's increase to outbreak proportions by 2 weeks or more.

Further work has been done on the pear thrips on prunes in cooperation with the Oregon Agricultural Experiment Station. In one heavily infested orchard two applications of a 2-percent miscible-oil emulsion with nicotine sulfate gave a yield of approximately 6 tons of fruit per acre as compared with less than a ton from the unsprayed trees.

PEACH INSECTS

Data obtained on the parasites of the oriental fruit moth at Moorestown, N. J., definitely support the prevalent impression that high parasitization of the larvae of the twig-infesting broods is a most important factor in reducing subsequent fruit infestation in mid-season varieties of peaches. In three groups of orchards in which 77, 63, and 51 percent of the twig-infested larvae were parasitized, the harvested fruit was infested 4, 15, and 30 percent, respectively. Mass-liberation experiments associated with this work indicated that early season parasitization can be substantially increased by the liberation of comparatively small numbers of parasites.

Recovery collections, in cooperation with State agencies, were continued as during previous years. The more significant features resulting from this work were that parasitization, particularly of the first brood, increased over any previous year; that the parasitization by *Macrocentrus ancylivorus* Roh. is still increasing; and that the parasitization immediately after the release of *Bassus diversus* Mues. did not increase to so great an extent as in the case of *Inareolata molestae* (Uchida).

Ethylene dichloride emulsion has continued to give effective control of the peach borer with little or no injury to peach trees, in work carried on chiefly near Fort Valley, Ga. Since ethylene dichloride is effective at low temperatures, it can be used both earlier and later in the season than paradichlorobenzene, which requires moderately high soil temperatures for satisfactory results. Because it is easy to apply and is comparatively safe, this material is being rapidly adopted by commercial growers.

In laboratory experiments with the plum curculio conducted during 1938 at Fort Valley, Ga., solutions of dichloroethyl ether gave almost complete kills of the insect in the soil. Similar results were obtained in experiments carried on in cages over peach treees where 1,000 curculio larvae were placed in the soil under each cage. At the strengths used, the treatment caused no apparent injury to the trees.

The work to determine the insects responsible for the transmission of the phony peach disease and peach mosiac has been continued. The surveys carried on with trailer laboratories have indicated a number of insects that there is reason to suspect may be the transmitting agents of these diseases, and this has made necessary the establishment of fixed laboratories to study the host-plant relationships and to conduct transmission experiments with these suspected insects. This work is being carried on at East Chattanooga, Tenn., at San Bernardino, Calif., and at Brownwood, Tex., in cooperation with the Division of Domestic Plant Quarantines and the Bureau of Plant Industry.

GRAPE INSECTS

An all-season treatment with phenothiazine gave a high degree of control of the grape berry moth at Sandusky, Ohio, under conditions of extremely heavy berry moth concentration on a very light crop of grapes.

In cooperation with the Bureau of Agricultural Chemistry and Engineering, experiments were carried on to test the value of a vaporizing

sprayer in controlling the grape leafhopper. This outfit delivers the insecticide by means of a blast of steam requiring comparatively little water. The kill of the insects was definitely inferior to that obtained with the standard power machine. As the quantity of material delivered was increased, the control also increased, but the results did not equal those obtained with the standard power sprayer.

NUT INSECTS

The hickory shuck worm on pecan was found by the Albany, Ga., laboratory to have in part a 2-year life cycle. Fifteen percent of one lot of material that entered hibernation as larvae in 1936 appeared as moths during the second season. This 2-year cycle will enable the insect to bridge over years when a crop of nuts is not available for them. The insect breeds in phylloxera galls before pecan nuts have formed, and develops more rapidly in these galls than it does in pecan nuts. In field experiments nicotine sulfate, nicotine-bentonite, and phenothiazine did not give satisfactory control of this insect.

At Monticello, Fla., a single application of a commercial nicotine-bentonite mixture with summer-oil emulsion apparently reduced an infestation of pecan nut casebearers 69 percent, and a second application gave a control of 81 percent. Field applications of certain of the tar-oil distillates during the dormant period showed reductions in the population of nut casebearers in the first generation ranging from 37 percent for a 3-percent mixture up to 93 percent reduction for a 6⅔-percent mixture.

At Brownwood, Tex., it was found that the nut casebearer feeds extensively on the pecan buds and shoots before turning its attention to the nuts, indicating the necessity for spraying the buds and shoots as well as the nuts. In Florida a number of individuals were reared from eggs to adults on shoots and leaves. This offers a possible explanation of the occasional occurrence of severe infestations following years of nut-crop failure.

Experimental work in Texas during 1938 indicated that the problem of borers in the wounds caused by grafting improved varieties of pecans on native trees was materially aided by the inlay bark graft and the improved grafting waxes developed by the Bureau of Plant Industry. This method results in less borer infestation than the method of top working which has been in general use in Texas. The use of paradichlorobenzene in the grafting wax at the time the top working was done seemed to have no value in borer control. After infestation had taken place, however, the use of additional wax impregnated with paradichlorobenzene was found effective.

The survey work on filbert insects was continued by workers stationed at the Eugene, Oreg., laboratory. The so-called Catalina cherry moth (*Melissopus latiferreanus* Wals.), an important filbert pest, has been found to range in distribution from the Canadian border in Washington to Los Angeles County in southern California. Although the Catalina cherry moth is known to feed on a number of different plants, the survey thus far has revealed it in the Northwest only on filbert, hazel, and oak. In southern California it was reared from oak galls and from the fruit of the Catalina cherry.

DRIED-FRUIT INSECTS

In 1938 the Fresno, Calif., laboratory carried out several schedules for the combined fumigation treatment and shade-cloth protection of dried peaches on the ranch, repeating largely the experiments carried on in 1937. Completely unprotected peaches became 99 percent infested when stored in boxes on the ranch. Similar lots which were fumigated but unprotected by shade cloth also later became about 99 percent infested, indicating that fumigation alone cannot be depended on for protection. The combination of fumigation and shade cloth, however, eliminated practically all infestation. The use of shade cloth appears to be particularly effective immediately following fumigation, as soon as the fruit is boxed from the stacked trays. When cloth is used over the boxes much less is required than when drying fruit in stacked trays is to be protected.

By the use of a mechanical rotary net further information was obtained on the flight habits and seasonal abundance of various insects infesting raisins. Although the saw-toothed grain beetle is one of the predominant species of insects in stored raisins, only 180 specimens of it were captured in the air throughout the entire season. It is evident that this insect does not fly to any extent but moves from point to point by crawling. This suggests the possibility of the use of barriers to prevent the insect from gaining access to the stacks of raisins.

SUBTROPICAL FRUIT INSECTS

Further progress has been made by the Whittier, Calif., laboratory toward the development of a standard laboratory procedure for studies of fumigation for the California red scale that will permit more precise comparisons. The so-called resistant and nonresistant strains of this scale which for several years have been maintained under identical conditions in isolated chambers at the laboratory have continued to maintain their difference in susceptibility.

Two strains of the California red scale, one resistant and the other nonresistant to fumigation with hydrocyanic acid gas, appeared to be about equally susceptible to the action of methyl bromide. The stages of the red scale that are most resistant to hydrocyanic acid gas appear to be the least resistant to methyl bromide. As far as can be determined, the phenomenon of protective stupefaction does not exist with methyl bromide. Promising results have been obtained in preliminary experiments in fumigations with mixtures of hydrocyanic acid gas and methyl bromide.

Field tests of oils with added toxicants, carried on in California in 1938 for the control of the California red scale, confirmed the results of preliminary tests in 1937 and indicated that the addition of nicotine or of cube extract to mineral-oil emulsions caused a marked increase in their effectiveness. This increase in effectiveness from the addition of toxicants seems most evident among the scales on wood, where the oil alone is less effective. Among numerous materials tested as mutual solvents between cube resins and oil, a trichloroethylene dibutyl phthalate mixture was the most satisfactory.

Special attention has been given by the Orlando, Fla., laboratory to the relation of particle size in wettable sulfur and sulfur dusts to

adhesion and control of the citrus rust mite. A 2,000-mesh sulfur dust applied at the rate of ½ pound per tree gave longer protection against reinfestation than the standard 325-mesh sulfur dust at 1 pound per tree. A specially prepared wettable sulfur of 4,000-mesh particle size, used in a spray at 5 pounds per 100 gallons, with or without added adhesives, gave much longer protection than 325-mesh wettable sulfur used at the same rate, or even in twice the amount. No harmful effects were seen on the trees, but further experiments will be needed with these promising new combinations.

In the control of the citrus thrips on lemons in California a sulfur-dusting program which extended through the summer, with reduced quantities of material as the weather became warmer, gave satisfactory control. During the past season only a slight trace of sulfur burn was noted in the test plots. A number of materials other than sulfur have been tested for thrips control. A very effective method of rearing citrus thrips under laboratory conditions has been worked out.

A further determination has been made by the Orlando laboratory that sprays, such as bordeaux mixture or hydrated lime with a sticker, that leave heavy noninsecticidal residues on leaves and fruit increase the populations of the purple scale and Florida red scale. The application of an ammoniacal copper carbonate, which leaves practically no residue, failed to result in scale build-up, and the increase was negligible in trees receiving no sprays.

In May 1939 the Florida laboratory was moved from Orlando to St. Lucie, near Fort Pierce, on the east coast. At that point greater attention will be given to methods of controlling whiteflies and scale insects, especially the Florida red scale. With St. Lucie as headquarters it will also be possible to devote more time to work with the papaya fruitfly and other pests of tropical fruits other than citrus.

JAPANESE AND ASIATIC BEETLES

The work on Japanese and Asiatic beetles has been continued by the laboratories at Moorestown, N. J., and Spencer, N. C. The area infested by the Japanese beetle increased in size about 1,266 square miles during 1938 and now covers approximately 15,117 square miles. The outstanding features of the 1938 season were an unusually light infestation in the oldest infested area, near Philadelphia, a somewhat lighter infestation in much of New Jersey and eastern Pennsylvania north of the Schuylkill River, and the occurrence of extremely heavy infestations in northern Delaware, northeastern Maryland, and southeastern Pennsylvania, as well as a striking increase in infestation in the metropolitan New York area.

Several rotenone-bearing materials were found to have approximately equal value as repellents for adult Japanese beetles. Efforts have been made, but without success, to determine the nature of the ingredient in these materials that is responsible for the repellency.

It was found that the standard bait, containing geraniol and clove eugenol, decreased in attractiveness to the adult beetles during the season after the first week of exposure. The function of the eugenol appeared to be largely to retard the loss in attractiveness of the geraniol itself, rather than to increase its initial attractiveness. The

inclusion of phenyl ethyl alcohol in the formula was found to interfere somewhat with the stabilizing action of the eugenol.

By a recently developed method for the biological assay of soils that have been treated with lead arsenate for grub control, soil from various points in the Middle West, where 1,000 pounds of lead arsenate had been applied a few years ago for grub control, appeared to contain the equivalent of 675 to 800 pounds of freshly applied lead arsenate, indicating a reduction equivalent to the loss of 200 to 325 pounds of lead arsenate. A basic zinc arsenate was found to be only slightly toxic to Japanese beetle larvae.

An investigation on the use of hydrocyanic acid gas as a fumigant for adult Japanese beetles in refrigerator cars was completed, and the dosage requirements for the fumigant at various temperatures from 45° to 75° F. were worked out. A method has been developed for forcing paradichlorobenzene gas rapidly through the soil of balled and potted plants to control the grubs of the Japanese beetle.

The studies of Japanese beetle parasites and their colonization in new areas have been continued by the Moorestown laboratory. About 9,500 *Tiphia popilliavora* Roh. females were collected in the summer of 1938 from 9 established colonies and the material used to provide for the liberation of 64 colonies in Maryland, 18 in Connecticut, and 12 in New York. Efforts to establish the Korean strain have been continued, since it is desirable to have a fall parasite species that will emerge late enough in the season to parasitize third-instar larvae of the Japanese beetle, thus complementing the work of *T. vernalis*, which attacks third-instar host larvae in the spring. In the spring of 1939, 145 colonies of *T. vernalis* Roh. were collected and liberated in 6 States. One colony of the dipterous parasite *Centeter cinerea* Ald. was released in Washington, D. C., in 1938, to determine the synchronization of this species with its host in a more southern area than those in which it had been previously liberated.

The milky diseases, which have received special attention, apparently occur rather generally through much of the older heavily infested area, although they have not been found at points of heavy localized infestation on its outer fringe, or at any point in New England. In experimental field plots first started in 1936 very high disease incidence and almost complete elimination of grubs have occurred.

Because of the difficulty in propagating these organisms in artificial media, it has been necessary to use the bodies of Japanese beetle grubs. A micrometer injection block has been developed with which 2,000 larvae can be inoculated per day. The spores of both type A and type B milky disease, after being stored 41 months in dried-blood films on glass slides in ordinary wooden slide boxes, gave as high infection by puncture inoculation as was obtained when the material was fresh.

A method of holding milky-disease material for subsequent field work has been developed at the Moorestown laboratory. Diseased larvae are ground and mixed with either talc or precipitated chalk, and the mixture is then passed through a 100-mesh sieve. The mixtures may be diluted with water and applied as a spray or mixed with soil and broadcast.

FRUITFLY INVESTIGATIONS

Studies in Hawaii on the vapor-heat method of fruit sterilization have resulted in data permitting the movement of papayas in the regular channels of trade. Heavy populations of the Mexican fruitfly appearing during the past year have been traced to the abnormal production of a second crop of *Sargentia*, a wild native host abundant in northeastern Mexico. Repellent materials discovered both in Hawaii and in Mexico offer a new possibility of protecting fruits from attack. In Puerto Rico a study of the movement of adult fruitfly populations indicates that attack on citrus is largely incidental, depending on the populations which may migrate, and that there is no continuous build-up in citrus.

MEXICAN FRUITFLY CONTROL

The citrus fruit industry in the Rio Grande Valley of Texas had an unprecedented crop of fruit and the largest number of larval infestations on record. The large crop of fruit necessitated a longer harvesting season, and the increased number of larval infestations made sterilization of citrus fruit of prime importance throughout the last half of the shipping season.

INFESTATIONS

Owing to the presence of an extremely large fly population, which apparently drifted into the regulated area from northeastern Mexico during January and February 1939, there developed in later months the most severe infestation of the Mexican fruitfly on record in the Rio Grande Valley. The situation was further complicated by the amount of fruit remaining to be harvested before the beginning of the host-free period, at a time when the fruit movement was delayed on account of poor market conditions.

Early in January traps indicated that flies were moving into the area, and by February it was realized that a serious problem confronted the growers, shippers, and quarantine personnel. Larval infestations were found in the regulated area late in February on 18 premises, in March on 1,404, in April on 704, in May on 3, and in June on 3. These infestations varied in intensity from 1 fruit found infested to as high as 10 percent of the entire crop on many plantings. On individual trees in numerous groves the damage amounted to 80 percent of the crop.

Outside the regulated area nine incipient infestations were found. Seven of these were found in Webb County, one in Dimmit County, and one in La Salle County.

It has long been recognized that the early termination of the harvesting season has a direct bearing on the amount of infestation which develops within the regulated area. When the crop was small enough to be harvested by March 1, little difficulty was encountered; but when production increased to such a degree that a large quantity of fruit remained to be harvested in March and April, infestations usually developed. During the past season it was necessary to extend the period for harvesting grapefruit through May 15, and as an abundance of fruit was available for oviposition, the resulting heavy infestation was not unexpected.

Table 1 shows, for the years 1935-39, the number of infestations in relation to the number of flies trapped and the date the harvesting season closed.

TABLE 1.—*Infestations of the Mexican fruitfly in Texas, 1935-39*

Fiscal year	Flies trapped	Larval infestations	Harvesting season closed	Fiscal year	Flies trapped	Larval infestations	Harvesting season closed
	Number	*Number*			*Number*	*Number*	
1935	367	30	Apr. 2	1938	[1] 712	218	Apr. 30
1936	251	5	Mar. 31	1939	[2] 13,687	[3] 2,141	[4] May 15 [5] June 15
1937	4,714	1,062	Mar. 31				

[1] 79 outside regulated area.
[2] 314 outside regulated area.
[3] 9 outside regulated area.
[4] For grapefruit.
[5] For oranges.

STERILIZATION

Although the infestation within the regulated area was higher during the spring of 1939 than in any other season, at no time throughout the year was the harvesting and shipment of fruit curtailed or seriously delayed. This was due to the fact that unrestricted shipments were permitted after the fruit had been sterilized.

Two types of sterilization were used in 1939, but the high-temperature method accounted for more than 99 percent of the fruit treated. The season opened with only a few rooms for high-temperature sterilization in operation, but more were added rapidly when infestations developed, and by the time the season closed 45 rooms were in operation, with a daily capacity equivalent to 87.2 carlots. Table 2 lists the amount of fruit sterilized monthly by the two approved methods.

TABLE 2.—*Citrus fruit sterilized in Texas* [1]

Month	By high-temperature method		By low-temperature method	Month	By high-temperature method		By low-temperature method
	Grapefruit	Oranges	Grapefruit		Grapefruit	Oranges	Grapefruit
	Tons	*Tons*	*Tons*		*Tons*	*Tons*	*Tons*
February	205.00			May	12,647.00	2.25	2.08
March	4,012.75						
April	27,285.25			Total	44,150.00	2.25	2.08

[1] Total equivalent carlots of fruit sterilized: 3,081.2.

CANNING PLANTS

The canning of grapefruit has continued to occupy an important place in the citrus industry and has become a factor of considerable importance in the enforcement of the provisions of Quarantine No. 64. The season's operations amounted to 12,272 equivalent carlots of grapefruit and 35 equivalent carlots of oranges.

SHIPMENT OF FRUIT

Commercial production of fruit in the regulated area (table 3) increased 12,621 equivalent carlots over the production of the pre-

ceding season. This amount, 47,548.4 equivalent carlots, includes fresh-fruit shipments, fruit processed, and fruit destroyed in the program of the Federal Surplus Commodities Corporation, and represents the highest commercial fruit production in the history of the citrus industry in Texas.

TABLE 3.—*Citrus fruit from the Rio Grande Valley, Tex., shipped and canned, and total production, in equivalent carlots, fiscal years 1933–39*

Fiscal year	By rail		By truck		By boat		By express and passenger car mixed	Canned grapefruit	Commercial production
	Grapefruit	Oranges	Grapefruit	Oranges	Grapefruit	Oranges			
	Carlots	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*	*Carlots*
1933	2,897	230	880	586	.....	.....	101	127	4,821
1934	1,748	114	1,236	877	.....	.....	99	240	4,314
1935	4,617	225	1,731	1,095	.....	.....	239	1,131	9,038
1936	4,262	600	1,454	1,182	.....	.....	267	1,682	9,447
1937	15,616	2,729	2,578	2,351	176	17	532	[1] 6,702	30,701
1938	13,736.3	1,322.7	2,817.4	1,991.5	183.1	4.7	596.1	14,278.6	34,927.4
1939	16,571.6	1,938.5	5,868.3	5,399.3	521.5	12.2	626	[2] 16,611	47,548.4

[1] Includes 2 cars of oranges processed.
[2] Includes 35 cars of oranges processed and 4,304 cars of grapefruit for diversion under the program of the Federal Surplus Commodities Corporation.

INFESTATIONS OUTSIDE OF REGULATED AREA

The discovery of nine incipient larval infestations and the trapping of flies in the counties of Webb, Dimmit, and La Salle necessitated making plans for including these counties in the regulated area. Citrus-fruit production in this territory is small in comparison with that in the regulated area, but it is scattered throughout the three counties.

JAPANESE BEETLE QUARANTINE AND CONTROL

TRAP SCOUTING IN NONREGULATED TERRITORY

During the summer of 1938 the regular trapping program for the Japanese beetle was carried on in 402 cities and towns in 18 States. At the seasonal peak approximately 97,800 scouting-type traps were in operation, and 345 trap inspectors were employed.

Throughout the season beetles were caught at 95 of the trapping points. Only 33 of the catches were first records, the remainder being from sparse infestations carried over from previous years.

Of the 33 first-record infestations, 9 were in Ohio, 8 in New York, 4 in Virginia, 3 each in Indiana, Maine, and North Carolina, 2 in Michigan, and 1 in Iowa. Many of these infestations consisted of 2 or 3 beetles.

From April to July the principal Bureau field stations throughout the United States were utilized in a Japanese beetle trapping survey. The only nonquarantined States not represented in this interdivisional field survey were Arkansas, Nevada, Oklahoma, South Dakota, and Kentucky. The results were negative in Alabama, Arizona, California, Colorado, Florida, Idaho, Kansas, Louisiana, Minnesota, Mississippi, Montana, Nebraska, New Hampshire, New Mexico, North

Dakota, Oregon, Tennessee, Texas, Utah, Vermont, Washington, and Wisconsin.

In cooperation with the University of Maryland Extension Division and the State entomologist approximately 40,000 traps, the majority manufactured in the Maryland penitentiary, were operated in Maryland during the summer. Trapping there was carried on in 89 cities, towns, and villages. Heavily infested areas were found in Cecil, Baltimore, Kent, Somerset, and Worcester Counties. First-record infestations were found in Jefferson, Lander, Queen Anne, and Ridgeville.

In Atlanta, Ga., 122 beetles were captured in 3,033 traps in 1938, as compared with 6 beetles in 1,487 traps in 1937. One beetle was caught in Savannah. Eighteen localities in the State were trapped, with negative results.

Beetles trapped in Chicago continued to show a decrease. A total of 330 were caught this year as compared with 384 during the summer of 1937. Evanston, Ill., also showed a smaller number (20 beetles in 1937 and 1 in 1938). In Cicero 5 beetles were trapped, as compared with 1 in 1937. The figure for East St. Louis decreased from 3 to 1. No beetles were found in Elgin, where 1 had been found in 1937. Twenty-three additional places in Illinois were trapped, with negative results.

A further decrease was shown for Indianapolis, Ind., where 21 acres were treated with lead arsenate in 1937. Finds decreased from 28 in 1936 to 12 in 1937 and 10 in 1938. The three first-record infestations for Indiana were at East Chicago, Elkhart, and Whiting. One beetle each was caught in Whiting and East Chicago and 2 beetles in Elkhart. The total number of beetles trapped in South Bend, Ind., in 1938 was 8 as compared with 43 in 1937. Twenty beetles were caught in 1,600 traps during 1938 in Fort Wayne. During the previous year half as many traps were used, and 18 beetles were captured. In Logansport, where a single beetle was found in 1937, 8 were trapped in 1938.

The Iowa first record was at Fort Madison, where a single beetle was caught. In each of the six other Iowa towns where traps were operated results were negative.

At Louisville, Ky., 62 beetles were caught in 1,566 traps, an increase from the 10 beetles trapped in 1937. At Lexington 597 traps were placed but only 1 beetle was caught. Approximately 600 traps were used at three other Kentucky points, but no beetles were collected.

First-record incipient infestations were found in Maine at Bath, Brunswick, and Ellsworth. At Bath two beetles were caught; one beetle each was found at Brunswick and Ellsworth. At Bangor three beetles were captured. A single beetle had been caught there in 1935 but none in 1936 or 1937.

During the summer 5,313 traps in Detroit captured 82 beetles. This was an increase over the 67 beetles caught in 5,045 traps in 1937, but still a decrease from the 128 found in 4,686 traps in 1936. First-record infestations were determined at Highland Park, where 2 beetles were caught, and at Pontiac, where a single beetle was found. A single beetle was trapped at Dearborn, a decrease from the 6 beetles of the preceding year.

Twenty-seven beetles were caught in St. Louis as compared with 1 beetle in 1937 and 88 in 1936. Traps set in 5 other Missouri communities failed to collect any beetles.

Of the eight first-record infestations in New York State, the only new infestations of an established nature were at Mount Morris and Brighton. Hornell, Rochester, and Watertown showed substantial increases in beetle collections.

First-record infestations in North Carolina of a few beetles each were recorded at Hamlet, Kinston, and Thomasville. Traps set in 19 other North Carolina communities revealed infestation in 10 cities and negative results in 9 others.

The first-record infestations at Dennison, Dover, and Newark, Ohio, were sufficient to warrant extension of the regulated area. At Ashtabula 397 traps were operated and 126 beetles were caught, approximately equal to the 129 beetles captured in 212 traps in 1937. Collections at Marietta decreased from 121 in 1936 to 45 in 1937 and 19 in 1938.

At Erie, Pa., 2,355 traps were operated and 343 beetles caught, as compared with 149 beetles caught in 1,964 traps in 1937. At Oil City approximately 400 traps in each year yielded 4 beetles in 1937 and 26 in 1938. Sharon showed an increase in beetles from 11 in 1937 to 177 in 1938.

Thirteen communities were trapped in South Carolina, with negative results from 11 towns and cities. The cities trapped with positive results were Charleston and Greenville, where 2 and 6 beetles, respectively, were caught.

In Virginia the 4 first-record infestations were of a few beetles each at Milford, 2 points on State Route 2 south of Fredericksburg, and at Warsaw. At Washington's Birthplace National Monument in Wakefield 7,422 beetles were collected in 300 traps in 1938, an increase over the 7,119 beetles caught in 15 traps in 1937.

Traps were operated at 15 West Virginia towns and cities during 1938; 12 of the communities showed negative results and the other 3 had increases in the number of beetles found. In Charleston a single beetle was caught in 1937, whereas 10 were caught in 1938. Charles Town showed an increase from 1 to 3 beetles, and Martinsburg trap catches increased from 5 to 14 beetles.

Trapping was started in 1939 on April 11 with the setting of traps at Presidio, Tex. On June 30 traps were in operation in 219 cities and towns in 34 States.

During May and June beetles were collected at locations in 31 towns and cities in Georgia, Illinois, Kentucky, Missouri, North Carolina, Ohio, and South Carolina. Nineteen of these towns and cities are in North Carolina. A single beetle caught at Martins Ferry, Ohio, was a first record. Six beetles were captured in Marietta, Ohio; 139 in Atlanta, Ga.; 8 in East St. Louis, Ill.; 5 in Louisville, Ky.; and 10 in St. Louis, Mo. Included in the North Carolina finds were 1 beetle in Hamlet and 1 in Thomasville, 2 of the 3 locations of first-record infestation in North Carolina discovered during the 1938 season. Beetles in considerable numbers were captured in 4 North Carolina towns and cities which were not trapped during the summer of 1938. These towns and cities and the approximate beetle finds during May and June 1939 were as follows: East Spencer, 500; Greensboro, 200; Spencer, 300; and

Winston-Salem, 600. One beetle was caught in Milford, Va., the scene of 1 of the 4 first-record infestations in Virginia during the summer of 1938.

SUPPRESSIVE MEASURES

Soil-treatment programs were carried out in Georgia, Illinois, Indiana, Kentucky, Michigan, Missouri, New York, North Carolina, Ohio, Pennsylvania, and Virginia.

Field treatments were resumed in Atlanta, Ga., on September 7, and 35.2 acres received lead arsenate applications. Additional lead arsenate was applied to 15.8 acres between January 29 and February 15.

In Chicago 143.6 acres were treated between July 1 and October 19. Work on 52.8 additional acres was begun on May 22.

In Indiana, at Fort Wayne, 20.1 acres were treated; at Indianapolis, 6.5 acres; and at Logansport, 16.1 acres.

At Louisville, Ky., lead arsenate was applied to 35 acres.

Approximately 18 acres were treated in Detroit, Mich.; in Dearborn 13.5 acres received the lead arsenate treatment, and 1.2 acres were treated at Highland Park.

In St. Louis, Mo., 40.8 acres were treated.

Nurserymen in the Newark, N. J., area were responsible for the treatment of 1.6 acres in that city.

Lead arsenate applications at the principal Japanese beetle infestations discovered in North Carolina during the last few years were started in Greensboro and Winston-Salem on March 27. In Greensboro 69.7 acres were treated, in Winston-Salem 50.4 acres, and in Spencer 34.1 acres. Approximately 86 acres were treated at eight other North Carolina points, as follows: Charlotte, Durham, East Spencer, Elizabeth City, High Point, Raleigh, Sanford, and Wilmington.

At Marietta, Ohio, treatment was resumed on June 23, and 6 acres were treated. At Belpre lead arsenate was applied to 1.5 acres. Seventeen acres were sprayed at Ashtabula, Conneaut, and Mentor.

Field treatments were resumed on October 17 at Erie and Oil City, Pa. The work at Erie covered 81.1 acres, and at Oil City 16 acres had been treated when the work was completed on November 3.

At Winchester, Va., 10.2 acres were treated, and at Harrisonburg 2.1 acres received the treatment.

A total of 775 acres received the lead arsenate treatment at the places named. All the soil-treating projects were sponsored by State, city, or other agencies, with the Bureau furnishing the spray equipment, operators of the trucks, and supervisors to cooperate with the men designated by the States to supervise the labor.

FEDERAL AND STATE REGULATORY MEASURES

Administrative instructions dated September 19, 1938, advanced the date for termination of the restrictions as to fruits and vegetables from October 16 to September 20.

Revised quarantine regulations were issued, effective February 20, 1939. Nominal extensions were made of regulated areas in Maryland, New York, Pennsylvania, Virginia, and West Virginia, together with a more extensive increase in the Ohio regulated area. The revision also added parts of several counties in Pennsylvania and Mary-

land to the special area from which the movement of fruits and vegetables by motortruck or refrigerator car is regulated. Several isolated points in New York and Pennsylvania were placed under regulation, but no restrictions were placed on the movement of fruits and vegetables from these special areas. Fruit shippers were further relieved from restrictions on the movement of commercially packed peaches and of bananas in single bunches packed in commercial containers, unless they were moved by refrigerator cars or motortruck from the heavily infested area.

Revisions of existing intrastate Japanese beetle quarantine regulations were issued by the States of Missouri, North Carolina, Ohio, Pennsylvania, and Virginia.

HIGHWAY INSPECTION SERVICE

To meet the peak-month requirements for highway inspection of quarantined products, three stations were added in July to those already in operation at the end of the preceding fiscal year. By August 1, 1938, 39 roads were posted. Twelve of these were in Virginia, 6 in West Virginia, 10 in Ohio, and 11 in Pennsylvania. The highest number of road inspectors employed during the summer was 84.

Toward the end of August the first of the regular stations was closed for the season. As road traffic in quarantined products decreased, additional stations were abandoned. The last of the stations, that on U. S. Route No. 1, near Fredericksburg, Va., was closed on November 15.

In the spring of 1939 highway inspection began during the first week of April with the opening of 5 stations in Virginia and 2 in West Virginia. Later in the month 9 stations were posted in Ohio and 1 in Pennsylvania, bringing the total on April 30 to 17.

One station was opened in May, and 9 additional on June 15, when the seasonal restrictions on fruits and vegetables went into effect. All the 27 road stations were being operated at their maximum by the end of the month, manned by a total of 75 inspectors. Virginia had 14 stations, West Virginia 2, Ohio 10, and Pennsylvania 1.

Approximately 7,720 live adult beetles were found in empty trucks which were returning to southern points after having made deliveries in heavily infested northern sections. One truck that was on its way back from New York was found to have 234 beetles. On another truck from the same city 213 beetles were found.

Ninety-one lots of infested plant material were intercepted. From this plant material 26 adult beetles, 4 pupae, and 188 grubs were removed.

Counts of all motor vehicles stopped at the road stations for inspection totaled 4,897,793. Of this number, 26,382 were found to be carrying uncertified quarantined products.

CERTIFICATION AND TREATMENT OF NURSERY STOCK

Continued build-up in beetle population was again responsible for additions to the number of classified nurseries and greenhouses found to be infested with the Japanese beetle. In New England beetles were found on the grounds of 71 nurseries and greenhouses in Connecticut, 4 in Massachusetts, 1 in New Hampshire, and 1 in Rhode Island. The

other States in the regulated area reported nursery infestations as follows: Delaware, 8 establishments; Maryland, 72; New Jersey, 6; New York, 39; Ohio, 1; Pennsylvania, 26; Virginia, 27; and West Virginia, 2. A total of 5,562 beetles were found on the grounds of these 258 establishments. In addition, beetles totaling 673 were found within 500 feet of the grounds of 61 other establishments in the regulated area.

Fewer nurseries were rescouted in 1938 than in 1937, when this practice was inaugurated. In 1937, 67 establishments were rescouted; in 1938, 7. Of the latter number, 3 were found uninfested and were again assigned to the preferred status. Infestations on the other 4 properties were found to be limited to a portion of the nursery, giving these establishments at least a small area of preferred classification from which stock might be shipped without treatment.

Nursery and greenhouse scouting was completed during the third week in September.

On September 23, 10 live Japanese beetles, feeding on grape foliage in Elmira, N. Y., were found by an inspector in the course of special checking to determine how late beetles might be found in that section. An inspector brought in a live male beetle on November 8, collected on zinnia at Rumson, N. J. Another "last" beetle was found November 7 on a rose growing in a yard in Swarthmore, Pa.

Throughout most of the Japanese beetle regulated area large quantities of nursery products moved under certification for many of the quarantined States. Forty-two carloads of certified stock were shipped from New Jersey in March.

A number of temporary inspectors were added to the field force during March to take care of an increased demand for Japanese beetle inspection and certification of nursery and greenhouse stock. Five were employed to examine nursery stock shipped from the Newport, R. I., and Manchester, Conn., districts. With the arrival of Memorial Day the greater part of the spring nursery-inspection work was completed in the New England area. Only 1 of the 13 temporary inspectors employed in this work was retained after May 31. Throughout the area more shipments and a larger quantity of plants were presented for inspection and certification than for several years.

Numerous tests of methyl bromide as a fumigant for potted plants were conducted at commercial establishments during the winter of 1938–39. The tests were highly successful. As a result, methyl bromide fumigation was authorized, effective February 15, for potted plants, plants in tubs, or balled nursery stock with soil masses up to 8 inches in diameter. This new procedure is a decided boon to nurserymen. It is cheaper than either the carbon disulfide emulsion or paradichlorobenzene treatment. Nurserymen enthusiastically welcomed the new procedure as a simplification of fumigation methods for plants accompanied by soil.

A revised edition of the Shipper's Guide, enlarged to contain the cities and towns added to the regulated area with the revision of the regulations effective February 20, 1939, was distributed during the first part of May.

A total of 909 soil samples was collected from 99.96 acres of nursery plots, heeling-in areas, and frames treated with lead arsenate.

The Division of Insecticide Investigations analyzed these samples, and when a deficiency of lead arsenate was indicated, new applications of the poison were made to the areas showing the need for it. Throughout the Japanese beetle regulated area the re-leading of nursery plots was approximately one-half of the acreage treated in 1938. The analyses indicated very little loss of lead arsenate content during the year in those plots where the dosage was up to requirements last year. A number of the treated plots are being abandoned in favor of the methyl bromide fumigation of nursery stock. Initial applications were made to 10.97 acres of nursery plots and heeling-in sections.

A small increase was shown in the number of commercial establishments conforming to the requirements for classification. Class I listed 1,926 of these establishments, class III had 576, and the remaining 18 were in an intermediate classification. The number of uninfested nurseries increased by 89, but there was a net decrease of 96 in the number of infested properties.

Traps set in the Norfolk, Va., area to indicate early emergence for 1939 caught one beetle on May 29.

CERTIFICATION OF FRUITS, VEGETABLES, AND CUT FLOWERS

A maximum force of 177 men inspected farm products in the regulated area during the period of adult beetle flight in 1938. Forty-two inspection centers were in operation. Eight were in Delaware, 8 in New York, 6 in Maryland, 5 in Virginia, 4 in New Jersey, 2 in Massachusetts, 2 in Pennsylvania, 1 in Maine, 3 in Ohio, 1 in the District of Columbia, 1 in Connecticut, and 1 in West Virginia.

The heavy flight of Japanese beetles in July in the New York City district necessitated the fumigation of refrigerator cars loaded with bananas. This was the first time such a measure was necessary in the area. During July 262 loaded cars were fumigated with methyl bromide.

The flight of Japanese beetles in the Baltimore, Md., area was the greatest in years. More beetles were found on shipments of farm products and cut flowers in 1 day during July than in the entire inspection period of 1937.

Prefumigation and screening of refrigerator cars used to haul products from the generally infested section were discontinued September 10. The seasonal restrictions on fruits and vegetables were removed September 20. The restrictions on the movement of cut flowers continued in effect, however, until October 15.

During the period of the quarantine on fruits, vegetables, and cut flowers, inspectors removed 1,660 adult beetles from 5,087,088 packages of commodities certified for inspection.

CERTIFICATES ISSUED, VIOLATIONS INVESTIGATED, AND PROSECUTIONS TERMINATED

A total of 553,804 certificates of all kinds were used to cover quarantined products moving to nonregulated territory during the year.

Table 4 shows the quarantined articles, intended for shipment from the regulated area and for use in certified greenhouses or surface soil in nursery plots, in heeling-in areas, or in plunging areas, which were fumigated or sterilized during the 12-month period.

TABLE 4.—*Materials fumigated or sterilized under Japanese beetle quarantine regulations, fiscal year 1939*

Treatment	Plants	Potting soil	Sand	Surface soil	Surface soil with plants	Berries
	Number	*Cubic yards*	*Cars*	*Square feet*	*Square feet*	*Crates*
Lead arsenate	48,543			550,394	122,406	
Carbon disulfide	4,564	2,775	37	21,560		4,868
Paradichlorobenzene	75,587					
Naphthalene		80		39,089		
Steam		509		17,352		
Hot water	74					
Electricity		47				

Treatment	Plants	Potatoes	Sweet-potatoes	Onions	Tomatoes	Mixed shipments	Empty cars
	Number	*Cars*	*Cars*	*Cars*	*Cars*	*Cars*	*Number*
Methyl bromide	302,388	5,596	61	64	8	3	2
Hydrocyanic acid		81	1	55	3	1	5,629

Treatment	Apples	Bananas	Carrots	Cucumbers	Egg-plant	Peppers
	Bushels	*Cars*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Methyl bromide						
Hydrocyanic acid	75	633	25	50	129	1,331

Nursery and ornamental stock, sand, soil, earth, peat, compost, and manure were certified for shipment from class III establishments in the regulated area in the following quantities:

Plants	number	33,056,496
Sand, earth, and clay	carloads	1,815
Peat	pounds	24,352
Grass and stolons	square feet	3,612
Manure and compost	carloads	3

Fruits, vegetables, and cut flowers certified during the seasonal quarantine on these articles were as follows:

Fruits and vegetables	packages	5,016,025
Cut flowers	do	71,063

A total of 248,586 shipments were made by class I establishments to points in nonregulated territory and between establishments in the regulated area.

Investigations were made of 2,250 apparent violations of the Japanese beetle quarantine regulations. Convictions were secured for four of these violations. Three of them covered as many truckloads of uninspected sweetpotatoes intercepted at Rochester, N. Y. In the fourth case beetle infestation was found in the soil accompanying an uncertified forsythia plant intercepted at Los Angeles by an inspector of the California Department of Agriculture.

COOPERATIVE ENTERPRISES

State funds for cooperative control or quarantine activities were provided by Connecticut, Delaware, Georgia, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.

Total contributions from Federal welfare, State, city, and other agencies for labor and material used to set and remove traps were approximately $27,670 for the year; for soil treating, about $110,000.

Experiments to determine the effectiveness of the nematode *Neoaplectana glaseri* in controlling established infestations of the Japanese beetle were continued at White Horse, N. J., under the joint cooperation of this Bureau and the New Jersey Department of Agriculture.

Lead arsenate and labor for its application were supplied through a $30,000 appropriation by the State Assembly of North Carolina. In addition, $60,000 was appropriated for the succeeding biennium for soil poisoning in the State. For the first year of the biennium $35,000 was allotted, and for the second year $25,000, making a total of $90,000 appropriated by the 1939 General Assembly for Japanese beetle soil treatment in the State.

CONTROL OF PEACH MOSAIC AND PHONY PEACH DISEASES

Funds for prosecuting the peach mosaic and phony peach control projects were derived from regular appropriations, supplemented by substantial emergency-relief allotments and contributions from the States, the latter of which nearly equaled regular Federal appropriations.

Almost 16,000,000 orchard trees on more than 145,000 properties were inspected. In excess of 147,000 diseased trees were found, more than 120,000 of which were destroyed. While comparisons with previous years' findings are difficult, there is evidence of substantial reductions in incidence of new cases of these two diseases.

With labor employed with Emergency Relief Administration funds, between 9 and 10 million escaped and abandoned trees were removed to prevent their becoming harboring places for these diseases and to eliminate the necessity for subsequent inspections.

Inspections were conducted in 455 counties in 24 Southern States from the Atlantic to the Pacific. Four additional counties were found infected with mosaic and 7 with phony peach disease for the first time.

During the last quarter of the year inspections were made of nurseries and budwood sources and their environs. Nearly 700 nurseries growing more than 26 million trees were involved. In the States infected with phony peach all diseased trees were removed from all nursery environs before June 30, thereby complying with all requirements for certification under the standard State quarantines. In the mosaic area 31 nurseries and 7 dealers' sales yards failed to meet the requirements of the quarantines and were barred from shipping nursery stock. Most of the latter nurseries were producing stock for home use only. Cooperation was continued in assisting States in the enforcement of their standard quarantines relative to these diseases.

In cooperation with the Colorado State Department of Agriculture, a series of "off" variety peach trees were grafted with scions from

known healthy but susceptible varieties with a view to determining whether the grafted trees might be symptomless carriers. The practicability of this method of inspection will not be determined until the present crop season is over.

During the year 147 Bureau and 69 State inspectors were employed on the project, in addition to an average of nearly 650 relief workers.

After the 1939 inspection season the States of Maryland and Oklahoma were released from the area quarantined on account of phony peach disease, since no diseased trees were found by inspection during a period of 3 years of properties previously known to have been infected, and contiguous properties. Many counties in other States were also eligible for removal from quarantine. However, no action was taken by the States to remove these counties from quarantine, since all nurseries therein could comply with the quarantine-certification requirements.

CITRUS CANKER ERADICATION

Repeated and thorough inspection work was conducted in areas in Louisiana and Texas in which citrus canker had been found since the intensive survey of 1935, and the program was extended to include a number of additional counties. One recurring infection and one infection on a property in which disease had not previously been detected were found in Brazoria County, Tex. The 106 infected trees in these areas consisted of small seedlings, which in the case of the property not previously known to be infected had been cut off by a mowing machine. The discovery of infection under such circumstances is indicative of the thorough and intensive nature of the inspection program.

The employment of relief labor from allotments from emergency-relief appropriations made possible the removal and destruction of over 2,000,000 escaped and abandoned citrus trees, a large majority of which were *Citrus trifoliata* seedlings. This type of work is a very essential part of the eradication program, since it results in elimination of escaped and abandoned trees that might harbor the disease.

INSECTS AFFECTING FOREST AND SHADE TREES

PROGRESS MADE IN THE CONTROL OF BARK BEETLES

WESTERN PINE BEETLE

Recent studies in the commercial pine forests of California and Oregon have emphasized the development of methods of classifying forest stands as to their relative susceptibility to attack by bark beetles. It is believed that the danger of serious outbreaks may be greatly reduced by making forest stands more resistant to attack through selective cutting of high-risk trees and by giving priority in logging programs to areas of greatest beetle hazard. Large tracts of forest land have been surveyed and zoned as to relative degree of hazard, and it is planned to complete this work over practically all the commercial pine area. This information is of direct value to the Forest Service, the Office of Indian Affairs, and those owning large tracts of timber in planning their sales and cutting programs.

Much of the high-quality lumber in the commercial pine stands of northeastern California is contained in overmature trees, in varying

stages of deterioration due to poor growth and injury from certain forms of insect activity. It is considered that the prevalence of such trees serves as a breeding ground for endemic western pine beetle infestations which at times develop into epidemic outbreaks. Logging of trees infested with *Dendroctonus* beetles as a combined control and salvage measure has been tried at various times during the past decade by private timber-holding companies in these areas. Some control has been secured by the operations, but values of the salvaged material were seriously affected by degrade due to rapid development of blue stains in the logs following attacks by the beetles.

Results of the salvage projects led to the theory that logging highly susceptible but living trees before they could be infested by *Dendroctonus* beetles would be more effective both for control and salvage. This method offers two decided advantages over logging only infested trees: (1) The lumber product would not be blue-stained, and (2) those trees in which beetle populations breed up would be removed, and an indirect control effect would be secured against further outbreaks. In 1939 the California Forest and Range Experiment Station initiated logging of high-risk trees on its experimental forest of 10,000 acres in the Lassen National Forest. This operation was planned as an adequate test of the foregoing theory. In the spring of 1939 one of the larger lumber companies, acting on information supplied by the Bureau of Entomology and Plant Quarantine, followed suit. Plans of the company have been based on detailed information regarding those areas where high insect hazards exist and on estimates of the volume of high-risk trees that should be removed.

Both these logging projects are being followed with detailed studies to check on their control efficiency. Plots have been established in both treated and untreated areas, which will be observed for a period of years to determine the effect of the logging upon subsequent beetle infestation. These plot studies will show what trees die, what relative losses occur on treated and untreated areas, what types of trees should be removed, and what types of trees will be most likely to survive if left in the reserve stand. The operation of the private company will be more extensive than that on the experimental forest and will provide reliable cost data. Only the best of modern caterpillar and truck logging equipment will be used, and experienced woods laborers will be employed. The company plans to follow log grades of high-risk material through the mill and will make a comparison of the yield of values from this material with that from similar stands logged by the usual methods of cutting.

MOUNTAIN PINE BEETLE

Present methods of reducing outbreaks of the mountain pine beetle in lodgepole pine involve the use of fire. This practice is in many instances destructive and entails considerable expense in combating those fires which inevitably get out of control. To avoid the danger associated with the use of fire it has been necessary to conduct control projects at a season of the year when such operations are most expensive. To eliminate this objection to an otherwise satisfactory method of control, experiments have been conducted to develop a spray which, when applied to the bark of standing infested lodgepole pine, would penetrate the bark and destroy the overwintering

insect broods beneath. These tests were so successful that during June 1939 an experimental control project was conducted on the Grand Teton National Park in Wyoming.

BLACK HILLS BEETLE

The Black Hills beetle is the most destructive forest insect in the central Rocky Mountain region. Since 1935 it has caused widespread losses in lodgepole, limber, and ponderosa pines, and in many areas has already destroyed more than 80 percent of the trees over 6 inches in diameter at breast height and all trees over 18 inches in diameter. The volume of losses caused by this insect during the past 5 years is seven times as great as the total fire losses and nearly as great as the total volume of timber cut in Wyoming, Utah, and Colorado. The timber cut during this period in these three States was about 465 million board feet.

The treating of over 50,000 ponderosa pine trees for control of the Black Hills beetle in the central Rocky Mountain region during the year brings the total for the last 5 years up to nearly a quarter of a million trees. The bark beetles built up to epidemic conditions during a period of severe drought and correspondingly poor tree growth. These outbreaks have been fought vigorously and effectively to save the scenic and commercial stands of pine in the region from further devastation. The actual treating was done by the Forest Service, the National Park Service, and the Denver Mountain Parks Improvement and Protective Association under the technical supervision of this Bureau. At present it appears that in practically all the areas where control work has been conducted the heavy epidemic centers have been reduced to an endemic condition. However, there should be no let-down in the vigilant watch for possible new centers of infestation.

OTHER FOREST INSECT PROBLEMS

HEMLOCK BORER

A preliminary investigation in 1937 disclosed that about 100 million board feet of hemlock had died in stands on the Menominee Indian Reservation in central Wisconsin since 1930. At the same time it was apparent that most of the trees had been infested by the hemlock borer. In June 1938 a study was begun to determine whether the insect is primary or secondary and whether any control measures are practical. From the first season's observations it can be definitely stated that the hemlock borer is secondary, since it can successfully attack and reach maturity in only those trees that are weak or dying. Incipient borer galleries in wood laid on as early as 1902 indicate that this insect has been present in these stands for many years. It could not, however, develop an epidemic population until severe heat and drought conditions from 1931 to 1937 and several severe blowdowns had made conditions favorable for successful attack and a rapid increase in population. General observations in the spring of 1939 indicate less mortality of trees this year than last, due, it is believed, to the abundant rainfall and favorable growing conditions in 1938. However, more than one rainy season will be needed to alter noticeably the condition created by the prolonged period of dry years.

EUROPEAN SPRUCE SAWFLY

An intensive survey was conducted during the summer of 1938 in New Hampshire, Vermont, and New York to determine the status of the European spruce sawfly. In cooperation with State agencies all the principal spruce areas in these three States were inspected. Generally speaking, the survey showed that the spruce sawfly was present wherever inspections were made, but only four areas of heavy infestation were found. Two of these were in southern New Hampshire, one in central Vermont, and one in southern Vermont. In 1937 heavy infestations were located in northern Maine and reports from that State in 1938 indicated an increase.

In cooperation with the Society for the Protection of New Hampshire Forests between 5 and 6 million cocoon parasites (*Microplectron fuscipennis* (Zett.)) were reared in 1938. Colonies of this European parasite were liberated at every locality in New Hampshire, Vermont, and New York where sufficient larvae were found to indicate the possibility of successful establishment of the parasite. In Maine large numbers were also reared and liberated by State agencies.

Eleven species of sawfly parasites were received in small numbers from the Canadian Government. About half these were liberated in heavy sawfly infestations; the remainder were held for experimental work in laboratory rearing. Small numbers of four species of larval parasites and one cocoon parasite were successfully reared, but none of the species appears particularly adapted for large-scale propagation.

In the spring of 1939 an intensive study of the sawfly and the factors influencing its abundance was undertaken. Permanent sample plots were established throughout the Northeast to determine the effects of defoliation on different species of spruce, the differences in life history of the insect under varying climatic conditions, and the fluctuation in population from generation to generation.

INSECTS IN RELATION TO THE DUTCH ELM DISEASE

Collections of adults of the bark beetles *Scolytus multistriatus* Marsh. and *Hylurgopinus rufipes* (Eich.) that were attracted to felled elm trees have been made uniformly from six points in New Jersey during 1936, 1937, and 1938. These bark beetles were cultured to ascertain the percentage carrying the Dutch elm disease fungus (*Ceratostomella ulmi* (Schwarz) Buisman). The records are given in table 5.

TABLE 5.—*Numbers and percentages of the two elm bark beetles collected that carried the Dutch elm disease fungus*

Year	*Scolytus multistriatus*		*Hylurgopinus rufipes*	
	Collected and cultured	Carrying *Ceratostomella ulmi*	Collected and cultured	Carrying *Ceratostomella ulmi*
	Number	*Percent*	*Number*	*Percent*
1936	7,209	6.9	139	4.3
1937	9,706	5.8	612	2.5
1938	33,192	7.7	274	3.3

The large increase in numbers of *Scolytus multistriatus* collected in 1938 may be attributed to a marked increase in the available breeding material in the field. The amount of such material has been much reduced in 1939, and it is hoped that further increase in the beetle population will be checked. It will also be noted that there was an appreciable increase in the percentage of both species of beetles carrying the fungus in 1938 over that in 1937.

Laboratory and field studies have revealed that adults of *Hylurgopinus rufipes* frequently bore through the bark of living elm trees and contact the xylem. Much of this activity apparently takes place early in the spring before the spring vessels of the elms are mature and when chances of inoculation are less likely to occur. This partly explains why *H. rufipes* is less important as a carrier of the fungus than *Scolytus multistriatus*.

Water solutions of sodium arsenite, copper sulfate, ammonium bifluoride, copper nitrate, and copper chloride have been found effective in killing elm trees. When these solutions were injected into living trees in a foliar condition, they were effective in controlling attack by *Scolytus multistriatus* and *Hylurgopinus rufipes*. Copper sulfate solution has been used more than the other chemicals mentioned, and this at 60 grams per inch diameter (based on dry weight of the salt) on trees up to 12 inches in diameter at breast height.

Preliminary studies have indicated that a combination spray of lead arsenate and lime-sulfur when sprayed on elms in foliar condition is effective in repelling *Scolytus multistriatus* from feeding in the crotches. Some measure of success has been secured in killing bark beetle broods in elm logs by spraying the logs with fuel oil plus orthodichlorobenzene and fuel oil plus naphthalene.

GYPSY AND BROWN-TAIL MOTH CONTROL

Late in September 1938 the New England area, which is heavily infested with the gypsy moth, was visited by one of the most severe hurricanes in its history. This climatic disturbance resulted in dislodging many egg clusters of the gypsy moth, and it is possible that large numbers of them were carried, in whole or in part, by the tremendous force of the wind to territory heretofore uninfested by this insect. (The same may be true in connection with distribution, for short distances at least, of brown-tail moth webs that had already been spun at the tips of the trees in the infested area.) The wind-blown trees afforded general protection for the insect during the winter, and the snow cover was ample to provide protection in latitudes where extremely low temperatures prevailed.

This ground condition impeded the progress of scouting and clean-up work for control of this pest and added materially to its cost. Fortunately the acreage where trees were blown down in the barrier zone was confined to limited areas, but the territory east of it, particularly in the Connecticut River Valley and on toward the seacoast, not only suffered the greatest damage but furnished conditions favorable for continued infestation.

Throughout the year effective cooperation has been maintained with the State officials, the C. C. C. organization administered by the Forest Service, and the Government officials of Canada in dealing

with small gypsy moth infestations that occur on both sides of the international line at Calais, Maine, and St. Stephen, New Brunswick.

In July 1938, assembling cages used for attracting male gypsy moths were set up as follows: 2,097 in 32 towns immediately surrounding the infested area in Pennsylvania (these were put out and patrolled by Bureau employees); 498 in 17 towns in New Jersey, surrounding the location where the gypsy moth was last found in that State and along the New Jersey, Pennsylvania, and New York State lines. These were put up and patrolled by State employees. In New York 4,476 were placed in 28 towns between the Hudson River and the New Jersey and Pennsylvania lines. They were put up and patrolled by State and Bureau employees. From the total, 7,071 cages, 23 male moths were caught at 7 cages in 6 towns in Pennsylvania, and at 1 cage in a town in Ulster County, N. Y. The cages in Pennsylvania were all in towns that had been infested previously. Since that time the surrounding area has been scouted. Five small infestations have been found and treated, and in the other town no infestation was discovered. In New York scouting covering an area of approximately 2 miles surrounding the cage failed to indicate any infestation. During July 1938 material was secured for use in charging assembling cages in the summer of 1939; 8,025 charges were obtained and held in cool storage (35°–40° F.).

During the same month an attempt was made to determine the feasibility of estimating defoliation by using an autogiro. Territory was surveyed in several counties and the degree of infestation noted on topographical quadrangles. This method appears to give sufficient promise to warrant its continuance on a larger scale in the future. In the summer of 1937 the acreage defoliated was the highest ever recorded, aggregating 608,760 acres. In July 1938, after the records taken by ground and autogiro observation were combined, the total aggregated 393,613 acres. There was a large decrease in Massachusetts and some decrease in New Hampshire and Maine. Moderate increases in acreage occurred in Vermont, Rhode Island, and Connecticut. No defoliation was recorded in New York, New Jersey, or Pennsylvania.

In continuation of work inaugurated in 1936 relative to studying possibilities of autogiro use in gypsy moth control, an aircraft of this type was purchased and equipped with insecticide-distributing apparatus of a design resulting from these studies. This equipment was used in June 1939. Lead arsenate and fish oil, which were carried in separate storage compartments in the giro, were mixed as they were forced from the machine. One hundred acres of woodland were sprayed. Preliminary results appear to be satisfactory. These must be checked after the foliage is down. The distribution of the poison on the foliage was more uniform than has been noted previously with insecticides released from airplanes. It was evident that the equipment must be improved in order that all the poison released will be mixed with the fish oil, and work along this line is being continued.

Wind dispersion of small caterpillars of the gypsy moth is the greatest danger to the maintenance of the barrier zone. For a number of years records have been taken in and near it covering the temperature and the direction and velocity of the wind during the period when the caterpillars are small enough to be blown to new

locations. By correlating these records and using the field-scouting data secured in the control work, the conclusion has been definitely reached that during the last 2 years weather conditions coupled with severe infestation in the Connecticut River Valley have been unusually favorable for wind spread toward the north and northwest. In scattered locations in the zone many colonies of a single egg cluster have been found that could not have become established in any other way.

A relatively small amount of work has been done on the brown-tail moth, although contact has been kept with the State and local organizations working on this problem. In some sections of Maine, New Hampshire, and Massachusetts, the only States now known to be infested, this insect has been destructive, and there has been a general increase in abundance during the year.

The regular appropriation of $275,718 supplemented by W. P. A. work-project allotments of $945,970, provided funds for the continuation of Federal gypsy moth control work. The regular funds were $25,000 less and the W. P. A. allotments approximately $351,000 less than were provided for gypsy moth control in 1938. With the W. P. A. funds available in 1939 an average daily force of 1,162 workers was employed, practically all of whom were drawn from relief rolls.

SCOUTING AND TREATMENT FOR THE GYPSY MOTH

As a result of intensive check-up work at sites of infestations discovered in the New England section of the barrier zone and in Pennsylvania during the fiscal year 1938, it was determined that 50 infestations had been exterminated in the Massachusetts portion of the zone area, 32 in the Connecticut section, and 89 in the Pennsylvania area, a total of 171.

Sites of infestations located in 1938 in the towns of Calais and Princeton in Washington County, Maine, were intensively scouted by a small force of experienced employees. No evidence of the gypsy moth was found in Princeton, but three small infestations were located and treated in Calais. In cooperation with the authorities of the Dominion of Canada responsible for pest-control work, these infested sites were sprayed in June 1939.

Work in Vermont was confined to the barrier zone and to a few towns east of Rutland where the danger of wind spread into the zone seemed greatest. Forty-one infestations aggregating 47 egg clusters were found in 6 towns in Addison County. This indicates that in the spring of 1938 there was considerable wind spread of young caterpillars from heavily infested areas near the Connecticut River up the White and Black River Valleys and into the barrier zone. One high-power sprayer was used in June in treating several infestations on high elevations in towns adjacent to the zone east of Rutland. The Connecticut River Valley towns in Vermont and New Hampshire are heavily infested from the Massachusetts State line approximately 100 miles north to Newbury, Vt. Within this territory extensive areas of heavy feeding have been observed this year.

In Massachusetts 65 percent of the W. P. A. field force was employed in the barrier zone in Berkshire County. The remainder of the work was done in selected areas, most of which were adjacent to the zone in

Franklin, Hampshire, and Hampden Counties. About the same number of infestations were found in the zone area as in 1938, but all were small, and the total number of egg clusters destroyed was less than one-half the number treated last year. Although fewer egg clusters were located east of the zone than previously, most of them were in lightly infested territory but were on high elevations, which are favorable for wind spread. Nine of the fourteen sprayers assigned to the Massachusetts area were used in the barrier zone, and the remainder were needed to treat serious infestations adjacent to the zone. Infestation between the zone and the Connecticut River is heavy, particularly in towns near this river, where several large areas were defoliated this year. Such infestations west of the river menace the barrier zone.

Practically all work in Connecticut was confined to the area of the barrier zone. Although more infestations were discovered there than in 1938, the total number of egg clusters located and treated was 55 percent less than the total destroyed last year. Twelve high-power sprayers were used this year. Late in June the State entomologist reported an isolated infestation within the zone in the town of Southbury. The pest was abundant, and a few trees showed noticeable feeding at the time the discovery was made. As it was too late to spray effectively, burlap was applied to the trees and caterpillars and pupae were crushed.

In New York intensive scouting and treating work was done by Federal W. P. A. forces, C. C. C. camp enrollees, and regular State employees supervised by the New York Conservation Department. Serious isolated infestations discovered near the zone in Shawangunk, Ulster County, and Hague, Warren County, in 1937 and 1938, respectively, have been suppressed. Excellent progress has also been made within the barrier zone, especially in further reducing the sizable infestation discovered in Putnam Valley, Putnam County, in 1937. A small isolated infestation exists in Yonkers, Westchester County, but no evidence of the gypsy moth was located in the boroughs of the Bronx and Manhattan, and on Long Island only 7 infestations, totalling 47 egg clusters, were found and treated. Seven Federal high-power sprayers were used in the New York area.

Inspection and certification of nursery stock and forest and other products at time of shipment was discontinued in the Long Island area on May 31, 1939. The New York Department of Agriculture and Markets will inspect and certify all nursery properties within the previously regulated area at least once each year and safeguard shipment of stock.

Work in Pennsylvania was confined chiefly to the centrally infested area where the gypsy moth is most abundant. Intensive work was also done at sites of infestations discovered last year in outside territory and within a ½-mile radius of assembling cages at which adult male gypsy moths were taken during the summer of 1938. Spraying of the infested residential areas was begun on May 22, and woodland spraying started June 1. A total of 35 high-power sprayers were used on this work. Spraying was discontinued before the end of the work period in June because the supply of lead arsenate was exhausted.

The Pennsylvania State quarantine on account of the gypsy moth has been strictly enforced, and 16 shippers were prosecuted and con-

victed of violating the State quarantine law. Approximately 32,500 shipments originating within the generally infested area were thoroughly inspected and certified as free from this insect before movement was permitted, and about 42,000 shipments originating in the lightly infested area were moved under permit during the year.

GYPSY MOTH WORK BY CIVILIAN CONSERVATION CORPS

This Bureau has continued to supervise C. C. C. gypsy moth work in part of the area between the barrier zone and the Connecticut River in Vermont, Massachusetts, and Connecticut, and cooperation has been maintained with the various State, Federal, and C. C. C. officials.

After the hurricane of September 1938 the daily average of enrollees available for the work dropped from 499, which was approximately the same as at the end of the previous year, to 169. This amounted in man-days for the year to a reduction of 56 percent.

At the beginning of the year men were available from 11 camps (2 in Vermont, 4 in Massachusetts, and 5 in Connecticut), while at the close of the year they were furnished by only 4 camps (2 in Massachusetts and 2 in Connecticut). All work was discontinued in Vermont soon after the storm, and the reduction in Massachusetts was very severe, as 2 of the camps removed worked exclusively on gypsy moth control.

The drastic reduction in manpower made it impossible to approach the completion of the work plan. Scouting and burlapping were drastically cut, and the men were concentrated in areas of especially heavy infestation. Many areas that needed follow-up work were left untouched. If the work could have continued, as planned, further work in some areas could have been discontinued for several years.

The severest and most extensive defoliation that has ever occurred in the area between the barrier zone and the Connecticut River in Vermont, Massachusetts, and Connecticut developed in the summer of 1938. Work was planned in these and adjoining areas during the present year but could not be carried out because the force was reduced.

Some work was done in 38 towns (6 in Vermont, 12 in Massachusetts, and 20 in Connecticut), and some infestation was found in all with the exception of 2 in Connecticut. As much of these areas as possible was treated.

Approximately 62,000 6-hour C. C. C. man-days were used. Most of the work was done in very heavy infestation, so that slightly more than 25,000 acres were covered. About 1,650 acres of woodland were thinned, and approximately all the brush from this operation was burned. Over 8,800,000 new gypsy moth egg clusters were destroyed, about 1,600,000 of which were burned in brush piles. In addition, burlap bands were applied to over 52,000 trees, and more than 3,400,000 gypsy moth caterpillars and pupae were destroyed.

Intensive work was done on 515 acres in the main infestation of a large woodland block in the Granby-Simsbury-Canton section of Connecticut. On this acreage over 7,068,000 new gypsy moth egg clusters were destroyed by creosoting and burning. The work consisted of piling the forest debris and of chopping out much of the undergrowth, especially of the favored-food-plant species. This ma-

terial was burned, egg clusters that could be reached with an 18-foot pole were creosoted, and many trees were climbed to complete the operation. The infestation was so severe in this district that many broken egg clusters and those on fallen leaves could not be treated, and many caterpillars hatched in the spring. The treatment applied prevented a large number of colonies from being established by wind spread. In some parts of the 1,500-acre area trees were nearly defoliated before spray could be applied. Recent examination of the area shows a great reduction in the infestation, although some new egg clusters are present around the edges of the sprayed area and in adjoining woodlands.

The C. C. C. gypsy moth work has been very helpful, and areas are in good condition where work plans have not been interrupted. There has been very severe increase in defoliation in many areas where work could not be done. To make substantial progress more manpower with adequate supervision is needed in the territory where these camps are operating.

Table 6 gives a consolidated report of scouting and treating done by the Bureau during the year.

TABLE 6.—*Gypsy moth control work, fiscal year 1939*

State	Project	Scouting							Thinning		Feneing		Banding			Spraying		
		Open country scouted					Woodland scouted	Egg clusters creosoted	Woodland thinned	Trees cut in open	Erected	Removed	Burlap bands applied	Pupae crushed	Larvae crushed	Woodland sprayed	Residential properties sprayed	Trees in open sprayed
		Open areas scouted	Roads	Apple trees	Oak trees	Shade trees												
		Acres	*Miles*	*Number*	*Number*	*Number*	*Acres*	*Number*	*Acres*	*Number*	*Feet*	*Feet*	*Number*	*Number*	*Number*	*Acres*	*Number*	*Number*
Maine	Regular	3,455	18	1,775	170	28,460	143	10	0	0	0	0	125	0	0	0	34	1,225
Vermont	W. P. A. and regular	144,662	779	133,231	9,412	326,806	338,107	102	1	150	60,260	0	6,248	8	7	176	16	0
	C. C. C.	195	2	185	0	110	2,060	36,356	91	260	0	0	0	207,328	508,871	0	0	0
Massachusetts	W. P. A. and regular	55,417	663	77,349	6,072	78,329	120,183	8,984	494	167	412,751	392,196	78,634	687,191	7,839	1,464	49	515
	C. C. C.	2,722	42	6,105	3,718	6,439	12,580	1,180,960	1,073	1,901	0	0	50,945	461,249	2,218,850	0	0	0
Connecticut	W. P. A. and regular	83,290	802	81,531	53,274	247,421	101,791	6,813	131	0	94,330	31,360	272,248	1,995	4,462	2,351	2	325
	C. C. C.	1,975	22	6,793	621	2,941	4,277	[1] 7,642,053	490	146	[2] 14,187	0	2,033	2,157	6,413	1,524	5	0
New York	W. P. A.	24,151	226	43,810	29,745	181,662	61,132	20	198	0	1,320	27,000	[3] 66,011	1	1,822	1	35	1,700
	State and C. C. C.	248,018	2,214	600,743	0	4,760,487	170,525	821	1,359	0	0	0	[3] 201,258	0	2,125	1,389	0	0
Pennsylvania	W. P. A. and regular	24,230	265	64,562	23,333	251,576	60,714	186,402	110	5	88,907	178,244	404,654	43,189	40,002	7,353	3,586	39,262
Total	do. [4]	583,223	4,967	1,003,001	122,006	5,874,741	852,595	203,152	2,293	322	657,568	628,800	1,029,178	732,384	56,257	12,734	3,722	43,027
	C. C. C. [5]	4,892	66	13,083	4,339	9,490	18,917	8,859,369	1,654	2,307	14,187	0	52,978	670,734	2,734,134	1,524	5	0
Grand total		588,115	5,033	1,016,084	126,345	5,884,231	871,512	9,062,521	3,947	2,629	671,755	628,800	1,082,156	1,403,118	2,790,391	14,258	3,727	43,027

[1] 1,683,265 estimated number of egg clusters burned in piles of debris included in Connecticut figure.
[2] Wire strung by State crew.
[3] A large percentage of the bands applied in New York were of sticky material instead of burlap.
[4] Includes State and C. C. C. work in New York.
[5] Not including C. C. C. in New York.

GYPSY AND BROWN-TAIL MOTH QUARANTINE ENFORCEMENT

REGULATORY CHANGES

On the basis of 3 successive years of negative scouting, it was possible this year to reduce further the gypsy moth regulated areas in New Hampshire and Vermont. This release of territory extended to 22 towns in Vermont and 4 towns in New Hampshire. This revision was of importance to Christmas-tree operators, since balsam fir and spruce are cut and shipped in quantities from these towns. It also released from regulation the important marble- and granite-shipping districts centering around Rutland, Vt. In all, considerable certification work has been eliminated by freeing this territory.

Increased gypsy moth infestation in parts of Maine, on the other hand, necessitated shifting a sizable block of towns in that State from the status of lightly to generally infested territory. Sections of six Maine counties were involved in the change. In addition, similar changes in status were made in several towns in three counties in Vermont and a few towns in a single New Hampshire county. None of the towns newly assigned to the generally infested classification are important as centers for Christmas-tree cutting.

These changes in regulated area were accomplished under a revision of the gypsy moth quarantine and supplementary regulations effective September 29, 1938.

CERTIFICATION OF QUARANTINED PRODUCTS

Continued heavy infestation in scattered sections of the generally infested gypsy moth area resulted in a further increase in the number of egg masses and other stages of the insect removed in the course of inspection of quarantined products. During the year inspectors removed 2,010 egg clusters, 150 larvae, and 74 pupae from products inspected and certified before movement to noninfested area. Typical removals in the course of an inspector's daily rounds were 32 egg clusters, 1 larva, and 29 pupae taken from a carload of lumber loaded at Westcott, Maine, for shipment to Toledo, Ohio, and 75 egg clusters creosoted and removed from a carload of birch firewood inspected as it was loaded at Cornish, Maine, for transportation to Philadelphia, Pa. A larger number of egg masses were removed from evergreen products than from either forest products, stone and quarry products, or nursery stock inspected during the year.

Twenty-three egg clusters were removed from 23,494 consignments of nursery stock certified during the year. Nursery products inspected were as follows:

	Number
Shrubs	3,057,352
Specimen trees	21,521
Young trees	207,657
Specimen evergreens	215,563
Young evergreens	2,976,643
Seedlings, cuttings, and small plants	3,298,294
White pine trees	301

Joint certificates for most of this material were issued under both the Japanese beetle and the gypsy moth quarantine regulations.

Cutting of Christmas trees started in New England on October 15. Inspection of Christmas trees in the lightly infested gypsy moth area was considerably delayed owing to the warm weather prior to November 25. Twenty temporary inspectors were employed for the period of Christmas-tree and greenery inspection, which was completed on December 24. There was a 55-percent decrease in the number of Christmas trees offered for inspection and certification as compared with the number in 1937. Curtailment of cutting operations, due to warm weather early in the season, accounted for most of the decrease. This reduction is partly accounted for, also, by the fact that a large oversupply of trees in 1937 glutted the markets and made the buyers more conservative in their 1938 bookings. The situation is further explained by the removal from the lightly infested regulated area of 26 towns in New Hampshire and Vermont.

From 18,457 separate lots of evergreen products examined 1,164 egg clusters, 3 larvae, and 1 pupa were removed. The record removal in connection with the season's inspections of evergreen-bough material consisted of 500 egg clusters found on 5 tons of boughs inspected at Cape Porpoise, Maine. Products in this category certified during the year consisted of the following:

Boughs, balsam twigs, and mixed greens	boxes or bales	39,641
Christmas trees	number	344,066
Laurel	boxes or bales	7,126
Miscellaneous	do	6,262
Do	yards of roping	4,950
Do	truckloads	1

During the year 21,441 shipments of forest products were inspected and certified. From these, 821 egg masses, 82 larvae, and 73 pupae were removed. Individual items certified in these shipments were as follows:

Barrel parts, crates, crating	cases, bundles	59,727
Logs, piles, posts, poles, ship knees, and ties	pieces	1,038,717
Fuel wood	cords	1,902
Pulpwood	do	30,934
Miscellaneous wood	do	134
Lumber	board feet	40,380,770
Empty cable reels	number	42,417
Shavings	bales	29,581
Shrub and vine cuttings	boxes	808
Lags	bundles	7,999
Miscellaneous	pieces	286,453
Do	carloads	80
Do	bundles, bags, boxes	1,033
Do	carloads and truckloads	14

A practicable method of ridding wood edgings of gypsy moth infestation in the process of converting them into chips or shavings was successfully worked out in consultation with an engineering firm. Need for such a procedure was imperative to facilitate the certification of a large quantity of wood shavings being shipped to Brooklyn, N. Y., by a lumber company in the heavily infested area. By installation of a new type of cutter and blower, shavings came through free of all traces of egg masses or individual eggs.

Stone and quarry products included in 20,264 lots examined during the year disclosed 2 egg clusters and 65 larvae. The contents of the shipments were as shown in the following list:

Crushed rock	tons	551
Curbing	running feet	34,873
Feldspar	tons	1,391
Granite	pieces	397,159
Do	tons	37,056
Monumental stone	pieces	19,512
Grout	tons	5,705
Marble	pieces	530
Limestone	tons	90
Paving blocks	number	600,913
Scrap iron	tons	184
Miscellaneous	pieces	4,379
Do	tons	324
Do	carloads	6

VIOLATIONS

Apparent violations of the gypsy and brown-tail moth quarantine totaled 1,122. Two prosecutions were terminated in convictions. One covered two consignments of spruce and hemlock cuttings from Winsted, Conn., to New York City without the required inspection and certification. The other case covered two consignments of birch logs from Worcester, Mass., shipped to Atlantic City, N. J., and Washington, D. C., respectively, without certification.

DUTCH ELM DISEASE ERADICATION

GENERAL STATUS

Several localized sections in New Jersey and Connecticut heavily infected with the Dutch elm disease accounted for a sizable increase in the comparative number of infected trees discovered during the year. Intensive elm-sanitation operations in these infection centers have destroyed the trees in which tremendous numbers of elm bark beetles, carriers of the disease, were hibernating. Elms infected with the disease were found in Pennsylvania for the first time in July 1938. Sporadic infections were discovered in additional towns in Dutchess County, N. Y., and in a number of towns in Orange and Ulster Counties, N. Y., outside the zone previously known to be infected.

Surveys in States remote from the main infected area failed to disclose a single new infection center. There was also no recurrence of the disease at Baltimore and Cumberland, Md., Norfolk and Portsmouth, Va., or Cincinnati and Cleveland, Ohio, where infected trees had been destroyed in previous years. Diseased trees found at outlying points were limited to 19 scattered cases in the Indianapolis, Ind., area, 4 cases in the Athens, Ohio, territory, and a single infection at Wiley Ford, W. Va.

Enforcement of the embargo on the movement of elm material from the infected territory listed in the regulations supplemental to Quarantine No. 71 continued during the year.

SYSTEMATIC SCOUTING

As revealed by the 1938 summer scouting, the principal spread of the disease was a short jump into Pennsylvania from the nearby in-

fected area in New Jersey, invasion of 2 tiers of townships in central New Jersey and southwestern Connecticut, and a more serious increase in the Dutchess County, N. Y., area. The Dutchess County infection is of particular importance because it brings the line of infection to within a few miles of the Massachusetts-New York State line. A total of 126 diseased elms were found in Dutchess County during the year.

Scouting during the 1938 foliage season, begun on June 13 in the previous fiscal year, continued until September 30, with a scouting force ranging from 1,682 to 2,445 men. During this period the infection of 15,909 elms with the fungus causing the disease was confirmed. These were divided as follows: Connecticut, 496; New Jersey, 14,216; New York, 1,157; Pennsylvania, 9; and outside States, 31. In comparison with confirmations during the 1937 scouting season, the cases in 1938 tripled in New Jersey and quadrupled in Connecticut, while fewer confirmations were found at the isolated infections. The number in New York was approximately the same both years.

From all sources 103,264 twig samples were submitted to the culture laboratory for identification. *Ceratostomella ulmi*, the fungus causing the disease, was cultured from 18,586 samples. Connecticut had 548 confirmations, New Jersey 16,752, New York 1,216, Pennsylvania 46, and outlying States 24. These totals represent increases of approximately 250 percent in both Connecticut and New Jersey combined, and reductions of 7 percent and 55 percent, respectively, in New York and outlying States, as compared with the previous year's confirmations. This year's confirmations added to the 6,500 cases reported last year and the 23,125 diseased trees found from 1930 to 1937 make a country-wide grand total of 48,211.

A severe concentration of infection was discovered during July near the border of the known infected zone in the Sourland Mountain section of Mercer, Hunterdon, and Somerset Counties, N. J. The wilt from the infection, plus the wilted, dangling twigs resulting from heavy crotch feeding by elm bark beetles, gave many of the trees the appearance of being infected with fire blight. All this section was intensively scouted during the rest of the foliage season. In Connecticut the northeastermost of the heavy, localized infections was found near Weston.

Scouting and sanitation activities in the infected sections in and surrounding Indianapolis, Ind., resulted in the location of only 19 infected trees as compared with 46 during the previous fiscal year. Other systematic scouting activities outside the regulated area were concentrated in the Athens, Ohio, area and the Cumberland, Md.–Wiley Ford, W. Va., area. Four disease cases were found at Athens, an increase over the number found the previous year. In Wiley Ford only 1 infected tree was found in the section where 5 had been located in the summer of 1937. Observations were also made to determine any reappearance of the disease at other isolated points at which infection had been discovered in previous years.

The infection of 161 trees in isolated infected areas has been verified. Of these, 104 are in Indianapolis, Ind.; 2 in Baltimore, 3 in Brunswick, and 1 in Cumberland, Md.; 6 in Athens, 1 in Cincinnati, and 33 in Cleveland, Ohio; 5 in Norfolk-Portsmouth, Va.; and 6 in Wiley Ford, W. Va.

There were two complete systematic surveys by scouts on foot in the older infected territory and in most of the newly infected sections that were added as the scouting progressed. Complete coverage in at least one survey and a partial second going over were made in the 10-mile protective zone. Surveys outside the infected zone were made by scouts on foot and scouts cruising in trucks and were supplemented by aerial observations in the remaining territory. Several special-problem areas in the Connecticut and New York infected zones were given a third going over.

Aerial mosaic maps of most of the sections of Connecticut, New Jersey, and New York in which scouting and eradicating were to be done were purchased for use during the 1938 scouting season. Use of these maps speeded up both the scouting and eradication work. By placing a dot on the exact tree affected and surrounding it with a circle, it was possible accurately to estimate distances from nearby landmarks by consulting grid lines photographed on the map at intervals of 4,000 feet. Eradication crews in turn were furnished with maps on which elms to be removed were spotted, and this enabled them to return to the exact spot by the nearest accessible road.

With the addition of another autogiro, five aerial scouting units were available for service in difficult scouting areas during the year. Activities of these units during the 1938 foliage season were largely a repetition of previous seasons' autogiro surveys but on an expanded scale. Single autogiro scouting units were assigned to the protective areas in Pennsylvania and New Jersey, and two of the ships and their accompanying ground crews worked in the more extensive protective zone in New York. The fifth aerial crew flew the railroad rights-of-way over which elm logs that introduced the fungus to this country travelled to midwestern veneer mills. Autogiro scouts were credited with the discovery of a number of the first-record infections in Dutchess County, N. Y.

On May 8 the culture laboratory at which the organisms infecting twig samples submitted by field workers are determined was transferred from Morristown, N. J., to the Bloomfield, N. J., field headquarters. Most of the necessary equipment was installed and in operation by that date.

In the spring of 1939 foliage wilt characteristic of Dutch elm disease infection was first observed in the field on May 16 on a small elm in Greenwich, Conn. In Dutchess County, N. Y., during the same week another instance of early-season wilt was reported. On May 26 characteristic wilting was observed on an elm near the Sourland Mountains, in Somerset County, N. J. Wilting was also observed late in June on an elm tree in Putnam County, N. Y.

Organization of a quota of 1,500 fully trained and capable scouts to be paid from regular Departmental funds made available in the Second Deficiency Appropriation Act began early in June. Approximately 2,300 men were notified to report for scout training on June 12. They were assigned largely to the infected areas, and their activities were in addition to the scouting work performed by the regular W. P. A. force.

EXTENSIONS OF WORK AREA

Additions to the infected zone as a result of the discovery of diseased elms in or just beyond the 10-mile protective zone surrounding the

known infected area included 41 townships, towns, and boroughs. These were as follows: In Connecticut, the towns of Bridgeport, Danbury, Easton, Newtown, and Stratford in Fairfield County, and the town of North Branford in New Haven County; in New Jersey, the township of Kingwood in Hunterdon County, and Ewing, Hamilton, and Lawrence in Mercer County; Howell, Marlboro, and Upper Freehold in Monmouth County; Stillwater in Sussex County; and Blairstown, Greenwich, Hardwick, and Knowlton Townships in Warren County; in New York, the towns of Clinton, LaGrange, Pawling, Pine Plains, Pleasant Valley, Stanford, Wappingers Falls, and Washington Hollow in Dutchess County; Greenville and Newburgh in Orange County; Patterson in Putnam County; and Esopus and Saugerties in Ulster County; and in Pennsylvania, the townships of Bridgeton, Buckingham, Falls, Lower Makefield, Solebury, Tinicum, Upper Makefield, and Wrightstown in Bucks County; and the township of Upper Mount Bethel and the borough of West Easton in Northampton County.

Expansion of the boundary of the infected zone to include all newly infected points added 1,730 square miles to the area, with a corresponding increase of 336 square miles in the 10-mile protective band. The major diseased area at the end of June comprised 493 square miles in Connecticut, 3,610 in New Jersey, 2,850 in New York, and 227 in Pennsylvania, a total of 7,180 square miles. The protective area included 758 square miles in Connecticut, 502 in New Jersey, 1,144 in New York, and 1,236 in Pennsylvania, totalling 3,640 square miles. The entire zone of field operations totaled 10,820 square miles, an area approximating in size the State of Vermont.

ERADICATION AND SANITATION ACTIVITIES

Activities of sanitation crews during the fall, winter, and spring consisted in removal of trees infected with elm bark beetles, individual dead and dying trees, and dead and dying trees, covered by a blanket permission for an entire section; intensive local sanitation in problem areas; clear cutting of elms in heavily infected areas; and destruction of elms in close proximity to trees confirmed as infected. Disposal of wood piles and the pruning of beetle wood were also activities of the sanitation crews. These operations had as their primary purpose the destruction of the fungus causing the disease and of material infected with the insect vectors of the fungus. Additional selective work comprised such activities as the creation of elm-free areas, through either clear cutting or other operations, to reduce costs and limit the extent of field activities.

Elms removed by the crews engaged in the various operations involved in eradication, sanitation, and selective work numbered 773,604. This reduction from last year's grand total of 1,206,000 trees removed was due to the fact that fewer W. P. A. workers were carried through the winter this year and that thorough sanitation activities were concentrated where they would be of the most benefit in either eradicating the disease or reducing the elm bark beetle population. The accumulative total of elms destroyed in the varied operations since the work was organized in 1931 is now 5,303,848.

Elm-sanitation work outside of the main zone of operations was centered at the three isolated infection centers in Indianapolis, Ind., Athens, Ohio, and Wiley Ford, W. Va. Several diseased trees were

discovered as elms were being removed in the vicinity of previous infections in the Indianapolis area. Initial clean-up work in Athens was completed in January. The sanitation area in the vicinity of Wiley Ford, W. Va., and Cumberland, Md., followed the Potomac River between Pinto and Spring Gap, Md.

One of the largest sanitation operations in the infected area was carried on in a large swamp in Patterson Township, Putnam County, N. Y. Over 10,000 elms of all sizes were removed from this 1,500-acre swamp. All elms within a 500-foot radius of an infected tree in the south end of the swamp were pruned.

Intensive elm-sanitation work was performed on all elm trees within a mile of the focal points of the disease in Dutchess County, N. Y.

Following the disastrous hurricane that swept over part of New England on September 21, sanitation crews in Connecticut were assigned to a rapid clean-up of the uprooted elms, trees with weakened branches and hanging branches, and elm debris that furnished ideal conditions for large increases in the insect carriers of the disease fungus. Most of this material was destroyed before the possibility of beetle emergence in May.

Tests were made to develop larvicidal material that may be used to destroy elm bark beetles infesting piles of elm logs that owners wish to keep under fuel agreements and will also serve as a repellent to these beetles when sprayed on freshly cut green logs that will upon drying become attractive to migrating beetles. Promising results were obtained with orthodichlorobenzene-naphthalene emulsion.

There were fewer fluctuations in the W. P. A. personnel throughout the year than previously. The number of workers ranged from 2,800 to 3,400 during the scouting season of 1938. From 2,900 to 3,300 men were retained in the eradication and sanitation activities until March. The first week in April the force was increased to approximately 3,650, and at this figure it was maintained for the rest of the year.

SOURCES OF FUNDS

Funds for operation of the eradication project were derived from a regular departmental appropriation of $378,489 and supplementary allotments made by the Works Progress Administration. The total was $2,957,500 for field work and $51,789 for administrative expenses. A further item of $100,000 was included in the Second Deficiency Appropriation Act of May 2, 1939, for the employment and training in mid-June of a large scouting organization.

Appropriations and allotments made by States engaged in cooperative eradication work amounted to $7,985 in Connecticut, $38,189 in New Jersey, $154,195 in New York, and $500 in Maryland. An estimated $5,000 from a State joint fund for Dutch elm disease, Japanese beetle, and European corn borer control was expended for Dutch elm disease work in Indiana. Two noninfected States, Massachusetts and Rhode Island, allotted $5,000 and $500, respectively, to Dutch elm disease research and surveys.

WHITE PINE BLISTER RUST CONTROL

RIBES ERADICATION IN 1938

The Bureau continued its program for the control of white pine blister rust in the United States in cooperation with State and local

agencies, the Forest Service and Soil Conservation Service of the Department of Agriculture, and the National Park Service and the Office of Indian Affairs of the Department of the Interior. The accomplishments summarized in this report include the results of the combined efforts of the Bureau and cooperating agencies.

During the calendar year 1938, 98,740,837 currant and gooseberry plants (*Ribes*) were destroyed on white pine forest areas in the United States totaling 2,234,849 acres. The treated acreage includes 1,547,426 acres on which only initial work was done and 687,423 that were reworked. The reworked acreage consisted of areas on which the *Ribes* were originally so numerous that it was necessary to go over them one or more times subsequently. This work is done at periodic intervals to maintain control conditions by destroying *Ribes* that have developed from seeds or sprouts and attained sufficient size to endanger the pines. Usually only portions of initially worked areas require two or more workings.

A large proportion of the *Ribes* eradication work has been carried on with relief labor. During the year this work provided 639,752 man-days of employment. The labor used by all cooperating agencies included 15,392 different individuals, of whom 6,892 were relief laborers, 6,657 C. C. C. enrollees, and 1,843 temporary employees of the Department and of cooperating State and local agencies. Where the work is in remote forest areas it is necessary to subsist the men in camps. Men from 298 camps were assigned to this work. Of these camps, 50 were relief-labor camps and 29 were occupied by temporary employees of the Department and cooperating agencies. Practically all these camps were on forest areas in the western white pine and sugar pine regions. In addition, C. C. C. enrollees in varying numbers were assigned to blister-rust control work from 219 camps, a large proportion of which were located in the Eastern States. The details of the *Ribes* eradication work are given in table 7.

TABLE 7.—*Ribes eradication work during the calendar year 1938*

Region	Initial eradication	Reeradication	Total initial eradication and reeradication [1]	Effective labor	*Ribes* destroyed
	Acres	*Acres*	*Acres*	*Man-days*	*Number*
Northeastern States	330,705	410,864	741,569	203,943	13,821,861
Southern Appalachian States	663,442	71,566	735,008	40,828	4,750,971
North Central States	405,518	70,295	475,813	79,563	18,700,421
Western white pine States (Idaho, Montana, Washington)	78,201	92,562	170,763	195,364	38,265,241
Sugar pine States (California and Oregon)	69,379	40,174	109,553	119,258	23,093,653
Rocky Mountain States (Colorado and Wyoming)	181	1,962	2,143	796	108,690
Total	1,547,426	687,423	2,234,849	639,752	98,740,837

[1] Includes work of cooperating Federal, State, and local agencies.

Of the acreage reported above, about two-thirds, or 1,530,703 acres, was worked by eradication crews paid from allotments of emergency-relief funds to the Bureau and to the Forest Service. The C. C. C. enrollees covered 487,542 acres, and the remaining 216,604 acres were worked by temporary employees of the Department and other cooperating agencies. Numerous States and townships provided appro-

priations for cooperation in control work on pinelands within their borders, the most substantial of such appropriations being those of New York and Idaho.

The work of the C. C. C. on the national forests was performed by enrollees from camps assigned to the Forest Service of this Department. The work on the national parks and Indian reservations was carried on by labor from C. C. C. camps allotted to the National Park Service and Office of Indian Affairs of the Department of the Interior. The C. C. C. work on private and State lands was performed in most cases by labor assigned from camps under the direction of State foresters and the Soil Conservation Service.

STATUS OF CONTROL WORK BY REGIONS

The beginning of large-scale control work and the rate of progress have varied in the different white pine regions. Prior to 1933 most attention was given to large-scale control operations in the Northeastern States, where the disease was most prevalent and was causing serious damage. In the other parts of the country, where the disease was either absent or progressing much more slowly, control work remained in the developmental stage.

Beginning in 1933, *Ribes* eradication in all white pine regions was stimulated and expanded through the use of emergency-relief funds. These funds became available at an opportune time, as the disease was reaching the damaging stage in all sections of the country except the sugar pine regions, and the need for increasing the scope of control activities was very presisng. Blister rust work not only afforded an opportunity for the use of a large amount of unemployed labor, but most of the funds were used for wages. These funds provided the control program in all regions with its first large supply of manpower. In addition, labor from C. C. C. camps was used wherever available within working distance of white pine stands needing protection. The status of control work at the end of 1938 is shown in table 8.

TABLE 8.—*Status of blister rust control work by regions on December 31, 1938*

Region	Control areas initially protected [1]	Control areas reworked subsequent to initial protection	*Ribes* destroyed	Effective labor
	Acres	*Acres*	*Number*	*Man-days*
Northeastern States	10,141,962	3,383,592	248,501,955	2,322,469
Southern Appalachian States	4,855,221	767,044	22,591,102	195,448
North Central States	2,484,512	197,694	186,806,819	713,965
Western white pine States (Idaho, Montana, Washington)	1,790,604	206,843	367,050,892	1,562,746
Sugar pine States (California and Oregon)	651,710	119,239	104,063,802	415,677
Rocky Mountain States [2] (Colorado and Wyoming)	36,619	1,962	1,583,306	13,896
Total	19,960,628	4,676,374	930,597,876	5,224,201

[1] The figures shown are net totals to Dec. 31, 1938, and do not include worked areas that were later removed from control-area status owing to their reversion to nonpine-producing types as a result of fire, cutting, or other causes. They are thus not strictly comparable with table 7 of the Bureau report for the fiscal year 1938.

[2] The work in Colorado and Wyoming represents experimental *Ribes* eradication in stands of limber, whitebark, and bristlecone pines on national forests to develop practical control measures for the Rocky Mountain region in advance of the spread of the rust. The acreages shown for these 2 States are not at present considered as part of the commercial white pine areas of the United States.

SPREAD OF BLISTER RUST IN 1938

Information on the spread of the disease is used in planning control work. *Ribes* eradication is carried out around local pine stands of sufficient value to justify the expense of protection, and such protection is effective regardless of the amount of disease in the vicinity. Blister rust control work, accordingly, is not primarily directed at retarding the spread of infection to new localities but is carried out, where practicable, to prevent injury to valuable pine stands before the disease arrives in a locality, as well as after it has become established in forest areas.

During the calendar year 1938 blister rust was found for the first time on either white pine or *Ribes* in 70 counties. Six of these counties are in the southern Appalachian States, 60 in the North Central States, 2 in Montana, and 2 in California.

In the southern Appalachian States the rust was found on white pine in Highland County, Va., and on *Ribes* in four counties in Virginia and one in West Virginia. These discoveries did not extend the spread of the disease farther south but added new counties within the previously known limits of infection in the southern Appalachian region.

The most extensive spread into new territory occurred in the North Central States, where weather conditions appeared to be more favorable for the dissemination of the rust. Infection was found for the first time on white pine in 8 counties in Ohio, Michigan, and Wisconsin and on *Ribes* in 55 counties in Ohio, Michigan, Wisconsin, Minnesota, Indiana, Illinois, and Iowa. In 38 of the 55 counties infection occurred on the cultivated black currant (*Ribes nigrum*). The large number of counties in which the disease was found on cultivated black currants indicates the importance of this species as a disseminator of the rust and the need for the eradication of these plants in regions where white pines are valuable forest and ornamental trees. The southern limits of the known infected area have been extended during the year from 1 to 3 counties in Ohio, Indiana, Illinois, and Iowa. In addition, many newly infected counties were added within the previously known limits of spread.

In Montana the disease was found widely distributed on wild *Ribes* on both sides of the Continental Divide. Infection was found at five different points where inspections were made in Glacier National Park. This represents an eastward extension of the rust into Flathead and Glacier Counties. Glacier National Park is situated within these counties.

During 1938 rust infection was found on *Ribes* in California 35 miles farther south than before and is now present about 160 miles below the Oregon-California border. Numerous other infections on *Ribes* were found within the sugar pine area previously reported as infected No rust was found on sugar pine south of the vicinity of the Oregon-California border, but since it takes from 3 to 4 years after infection for the resulting cankers to become easily discernible on pines, sufficient time has not elapsed since discovery of the disease in the State to enable the field men to find it readily on sugar pine. However, it is very probable that scattered pine infections exist in several sections of northern California.

One of the most significant finds on *Ribes* occurred in Shasta County, about 80 miles south of the Oregon line. In 1937 scouting activities in this locality uncovered only two diseased *Ribes*, each with but one leaf infected. A year later 300 infected *Ribes*, 50 of them *R. nevadense*, and the remainder *R. roezli*, were found to be heavily infected with blister rust in the same locality.

Again in Tehama County, west of Mount Lassen, 1937 scouting showed no infection, while in 1938 over 100 infected *Ribes roezli*, *R. inerme*, and *R. nevadense* bushes were found in a small localized area. Such discoveries, both in good association with sugar pine, have laid the foundation for centers of local infection on pines within the next few years.

WHITE PINE NURSERY STOCK PRODUCED FREE FROM BLISTER RUST INFECTION

Ribes eradication was carried on in the environs of 103 nurseries during 1938. These nurseries contained over 80,000,000 young white pines that were being grown for use in reforestation work. For several years nurseries producing white pine for forest planting have been examined annually to keep their environs free of *Ribes* by destroying any that may have developed from seeds or sprouts and thus assure the production of trees free from blister rust infection. This is important, as these trees are distributed widely for planting purposes and, if infected, would serve as carriers and spreaders of the disease. Most of the control areas around these nurseries have received from one to several workings, and although their protective borders are free of large bushes, in some cases seedlings and small bushes continue to make their appearance on portions of the protected areas.

During 1938 a total of 111,268 *Ribes* were destroyed on 45,346 acres in protection work around nurseries, or an average of about 2.4 bushes per acre. Many of these were seedling plants. Already the environs of some nurseries are so free of *Ribes* that they require only periodic inspections. The young trees are further safeguarded by arranging with planting agencies to have the reforestation sites examined for *Ribes* and such plants destroyed before the areas are planted with white pines. This assures protection to the new forest during the early years of its life. Young growth that remains unprotected is often completely destroyed by blister rust.

ERADICATION OF THE CULTIVATED BLACK CURRANT

An important phase of the Department's program for the control of blister rust consists in the eradication of the cultivated black currant (*Ribes nigrum*) in regions producing valuable crops of white pine timber. These currants are being eliminated because of their extreme susceptibility to infection and their importance in distributing the rust. Field observations show that they have been responsible for starting new centers of infection and firmly establishing the disease over extensive areas that otherwise might have remained free of the rust for many years. With few exceptions these plants are confined to gardens, from which they rarely escape. Hence they have not become established in our forests.

Owners of *R. nigrum* plants have given excellent cooperation in this work. Up to the present time 529,043 cultivated black currant bushes have been removed in the white pine regions of the United States. Half of these plants were found in the North Central States, 30 percent in the western white and sugar pine regions, 19 percent in the northeastern region, and less than 1 percent in the southern Appalachian States. During 1938, 15,935 cultivated black currant plants were eradicated, nearly all of which were located in the North Central States. The eradication of *R. nigrum* has retarded the natural spread of the disease both within and between white pine regions. This work is now nearing completion; although some of these plants probably will be found annually for several years, their influence in spreading the rust will soon have been reduced to a minimum.

TREATMENT OF INFECTED PINES OF HIGH VALUE

White pines have a wide use for recreational, ornamental, and esthetic purposes, and many such trees in public parks and around homes were attacked by blister rust before the disease-spreading currant and gooseberry bushes were removed. Methods have been developed for saving these infected pines by cutting out the diseased portions and preventing their reinfection by destroying any *Ribes* that may be present within 900 feet of the trees. The removal of the diseased parts of infected trees at Federal expense is restricted to ornamental and planted pines of high value in publicly owned pine stands and is not recommended as a control practice in native forest areas.

The treatment of infected pines was carried on during 1938 to a limited extent in the northern white pine regions of the Eastern States. In this work 92,358 white pines were saved by the removal of 171,731 cankers. In addition, 28,737 trees were destroyed because they were so thoroughly infected with blister rust that death was inevitable. This work involved the examination of 727,346 white pines and provided 5,478 man-days of employment.

WHITE PINE STANDS MAPPED FOR BLISTER RUST PROTECTION

White pines grow not only in pure stands but more often in mixture with other native species, usually of inferior value. In addition to forest stands there are numerous white pine wood lots, shelterbelts, plantations, recreational areas, and watershed-protection stands. Varying degrees of importance and value are placed upon these different white pine stands as encountered in the field, and good judgment is required in selecting those that justify blister rust protection. Commercial forest stands are selected for protection on the basis of their ultimate crop-production capacity at rotation age, and in determining this, consideration is given to forest and disease-control factors affecting the future of the crop. White pine shelterbelts, watersheds, and esthetic and recreational stands are considered on the basis of their value and practical utility for protective, recreational, scenic, and educational purposes.

During 1938 white pine stands and their protective borders totaling 2,785,235 acres were mapped for protection from blister rust. This

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work provided 50,495 man-days of employment. The maps are used in carrying on *Ribes* eradication and greatly increase the efficiency of control work.

IMPROVEMENT OF CONTROL PRACTICES

Prior to 1938 the primary objective of the work in developing methods for blister rust control for the western white pine region was the chemical eradication of *Ribes*. Now, the chief interest is in the possibility of aiding *Ribes* suppression through forest-management practices. This shift parallels the transition gradually taking place in the control work for the western white pine region which calls for increased attention to rework problems. The most urgently needed data seem to be those related to the regeneration of *Ribes* on areas where these plants were removed by mechanical or chemical means. Observations, therefore, are being made in cooperation with the Forest Service on the effect of different methods of stand improvement on the regeneration of *Ribes*. The germination of *Ribes* seed and the growth rate of established plants are being given attention as foundations for interpreting records of large-scale eradication and checking work.

In the sugar pine region preliminary tests of a horse-drawn *Ribes* grapple for eradicating *Ribes roezli* are encouraging. Also a bulldozer was planned and tested for working heavy concentrations of mature upland *R. roezli*. These tools gave sufficient promise to justify further developmental work. Data further indicate that dynamite will be cheaper than chemicals for certain large *Ribes* in nonrocky sites. Where bushes are rooted among large boulders or in rock crevices, the use of oil or dry chemical is a more practical and economical method.

CEREAL AND FORAGE INSECT INVESTIGATIONS

WHITE-FRINGED BEETLE

Studies of the white-fringed beetle (*Pantomorus leucoloma* (Boh.)) in 1938 rendered certain the fact that this insect normally produces but one generation annually. Physical development and rate of reproduction of this insect are governed importantly by the kind of plant food it obtains. Among the cultivated crops peanuts are found to be the most favored food plant. The average number of eggs laid by this insect when feeding on peanuts was 1,531, but the maximum number laid by any one beetle was 2,418. This will illustrate the extreme power of reproduction possessed by this pest.

The fallowing of large areas of farm land as a control measure resulted in preventing oviposition of the beetle and caused a great reduction in larval population subsequently. Experiments in the rotation of crops indicated that much heavier populations of the beetle followed peanuts, and corn intercropped with velvetbeans, respectively, than was the case with pure stands of corn or cotton. In the field adults were found to feed on 132 species of plants and the larvae or grubs on 175 species.

GRASSHOPPERS

Observations of grasshopper populations on eighteen intensive long-period study areas which are being conducted by the Bureau

indicated consistently that there has occurred a gradual decline in adult grasshopper populations in practically all the areas under observation during the period 1936–38. This decline, however, has not been reflected in general grasshopper conditions throughout the Great Plains States. The intensive studies have also shown that the greatest grasshopper populations were recorded during the years of minimum rainfall and that when precipitation reached normal amounts populations declined to a point where slight damage was to be expected. It was also demonstrated that general damage from grasshopper attack does not become apparent until there are present five or more hoppers per square yard.

A publication containing the applicable results of recent investigations of grasshopper control, Farmers' Bulletin 1828, was issued in June. It contains much new material on grasshopper control, including four optional formulas for the preparation of bait having as bases mill-run bran, mixed feed, or shorts; standard wheat bran; low-grade flour; or sawdust with molasses. Liquid sodium arsenite was the poisoning agent.

In extensive experiments with substitutes for wheat bran or sawdust in grasshopper baits, cottonseed hulls, citrus meal, and chopped alfalfa have given promising results. Chopped-alfalfa baits showed a tendency to form lumps and therefore cannot be recommended for general use until some way is found to overcome this tendency. The large-scale use of bran and sawdust substitutes also depends on their cost and availability in large quantities as compared with bran and sawdust.

The late summer of 1938 was marked by unprecedented flights of lesser migratory grasshoppers from western South Dakota into western North Dakota and eastern Montana, where they laid enormous numbers of eggs. In June 1939, contrary to all previous experience, it developed that most of these grasshoppers had deposited their eggs not only on cultivated and recently reverted lands but also on open range lands where countless millions of young hoppers appeared. Only the most rapid and vigorous action on the part of those in charge of grasshopper control, by the enlistment of a fleet of airplanes to distribute grasshopper bait, prevented a major disaster to crops. It was feared that great flights of hoppers would originate on these heavily infested areas to reinfest neighboring areas which had already been freed from hoppers by the distribution of poisoned bait. Fortunately, however, such flights as did occur were mostly to the northwestward, and no great damage to crops occurred from this source.

THE MORMON CRICKET

The standard method of control for Mormon crickets for many years has been to dust them with a mixture of sodium arsenite and lime or diatomaceous earth. This method is effective but laborious and, owing to the arsenical content of the dust and the class of labor necessarily employed in distributing it, involves considerable danger to livestock where carelessness in distribution occurs. Because of these defects, since 1935 efforts have been made to develop a poisoned bait that would be efficient for Mormon cricket control. Such a bait containing sodium fluosilicate as the poisoning agent was developed in 1938, but opportunity for testing it on a large scale did not occur

until the spring of 1939, when extensive field tests of this bait were conducted in Washington, Nevada, Wyoming, and South Dakota. These field applications resulted in the destruction of from 78 to 98 percent of the crickets. They demonstrated conclusively the effectiveness of this bait when distributed at a rate not exceeding 12 pounds to the acre. It is believed that the general adoption of this means of control will result in a reduction in operating expense and an increase in safety to livestock within the affected area.

INSECTS ATTACKING CORN

In 1938 a distinct general trend was observed toward increased populations of the European corn borer in a region extending from the Great Lakes eastward to Massachusetts and central Connecticut. Of particular significance in the Great Lakes area was the occurrence near Toledo, Ohio, of infestations averaging 17 borers per plant in early market sweet corn. This crop was severely injured in Lucas, Erie, and Huron Counties. Infestation rose rapidly in central New Jersey, particularly in Monmouth, Mercer, and Middlesex Counties, in parts of which occurred the highest infestations in field corn that had as yet been recorded in this country. A maximum infestation of 25 borers per plant was observed in 4 percent of the fields examined, 10 borers per plant in 21 percent, and 5 borers per plant in 57 percent.

In the breeding of strains of sweet corn resistant to the corn borer 398 inbred strains were tested at Toledo. Of these, 77 Golden Bantam, 12 Country Gentleman, and 4 Stowell Evergreen lines showed apparent resistance and were selected for further testing. Among the Bantam inbred strains tested in 1938 were 25 inbred selections of sweet corn segregates of a cross of inbred lines 39D and a field corn inbred line R4. Only 1 of these lines was found to be significantly below average in performance, and 2 were significantly above average.

In breeding field corn 32 of the 235 strains tested in top-cross combinations in 1938 were found to be resistant to the borer. Fifteen of these were tested both for first- and second-generation exposure. Of these, 13 carried their resistance through both generations, and only 2 of them showed a slight degree of susceptibility to attack by the second generation.

The artificial distribution of the natural enemies of the European corn borer has progressed steadily, and surveys made to determine the status of these parasites in 1938 in northwestern Ohio indicated that there has been a progressive increase in parasitization each year from 1932 to 1938, inclusive, of from 0.2 percent in 1932 to 20.9 percent during the past year.

An announcement was made in last year's report of the discovery of two practical methods of protecting ears of sweet corn from attacks by the corn earworm. These methods are effective particularly for early market sweet corn and home-garden purposes. One of them is the fumigation of the ear tip by inserting a small tablet of the chemical hexachloroethane and subsequently applying a simple wire clip to prevent the gas from escaping after application. The other consists in the injection of a very small quantity of light mineral oil into the ear. These new methods are fully described and illustrated in two publications issued by this Bureau, namely, The Use of Oil for

Earworm Control in Sweet Corn, E–476, issued in May, and Control of Earworms in Corn by Fumigation, E–485, issued in July 1939.

Although these methods are fully effective in their present state of development only for such ears as possess fairly long, tight husks, it is believed that improvements now under way will result in the near future in rendering these methods applicable to ears of average character.

INSECTS ATTACKING FORAGE CROPS

An insect pest of the sweetclovers and possibly also of alfalfa, *Hypera brunneipennis* Boh., new to the United States, was discovered at Yuma, Ariz., in April 1939 by entomological workers of the Arizona Agricultural Experiment Station. This insect, native to northern Africa, is very closely related to the alfalfa weevil now generally distributed throughout the Great Basin States, but apparently the new weevil is adapted to a subtropical environment. On the approach of the hot summer season it entered a state of estivation.

A survey to determine the distribution of the insect was immediately conducted, which revealed that the species was present in alfalfa, both in Arizona and in California, in the immediate environment of the Yuma irrigated section. An entomologist was detailed to study the biology of this new pest.

Preliminary observations indicate that this insect prefers the sweetclovers and fenugreek to alfalfa.

As the Yuma Valley is a commercial alfalfa-seed-producing area, an early requirement in connection with this infestation was the determination of the liability of dispersion of this pest through shipments of alfalfa hay and seed sent out of the infested area. It was found that, because of the small size of the alfalfa seed in comparison with the size of the adult insect, all the adults which passed into the threshing machine were killed. The indications are that very little danger is involved in such shipments. Methods of fumigating alfalfa hay for safe shipment are being developed.

In August 1938 a commercial seed analyst in Oregon discovered, in vetch seed originating in Clackamas County, live specimens of the vetch weevil (*Bruchus brachialis* Fahr.), an insect of foreign origin previously known in this country only from the Atlantic Coast States. This bruchid, a serious pest of vetch seed, lays its eggs on the young pods, and the resulting grubs enter the growing pods and destroy the developing seed. As the Willamette Valley of Oregon is the most important vetch-seed-producing area in the United States, the infestation of this area at once aroused great interest, but as the adult bruchid emerges from the seed late in July and early in August and immediately seeks hibernating quarters, which are as yet unknown, the delimitation of the area infested by the insect was necessarily deferred until the summer of 1939. A survey recently completed shows that this pest now is present in eight counties in Oregon, including practically all the Willamette Valley, and four counties in southern Washington.

Preliminary studies of the vetch weevil already conducted, mainly in North Carolina, indicate that, although this insect attacks several of the commercially important varieties of vetch, other varieties are either entirely immune or strongly resistant to its attack. Although this insect does not injure vetch for hay purposes, if it should prove

as injurious in the Pacific Northwest as in North Carolina, it may become necessary to discontinue the culture of susceptible varieties and substitute therefor such varieties as are immune to the attacks of the insect. Methods of fumigating seed for safe shipment are being studied.

INSECTS ATTACKING SMALL GRAINS

For several years the work of breeding wheats resistant to attack by the hessian fly has been progressing steadily. In 1938 the fly-resistant characteristics of Dawson wheat had been successfully transmitted, through the fourth back crosses, to Poso and Big Club for the production of commercially desirable fly-resistant wheat for use under California conditions. It is now believed that this work may be completed in 1944.

Similar work in the production of fly-resistant wheats for culture in the soft red wheat areas has progressed well. In an experimental nursery at La Fayette, Ind., containing 100,000 consistently resistant segregates, the resistant lines as a whole retained a greater plant vigor and more definite tendency to tiller than was the case with lines susceptible to fly attack. Other experiments indicated that fly-infested wheat plants are more susceptible to winter-killing than uninfested plants.

INSECTS ATTACKING SUGARCANE

It is estimated that the sugarcane borer, which is one of the principal limiting factors in the production of cane sugar in Louisiana, caused losses amounting to $4,700,000 in 1938. According to recent experimental work in the control of this insect by sprays containing cryolite, both the natural and synthetic forms of this chemical give approximately 90-percent control.

INSECTS AFFECTING STORED GRAINS

A study of the condition of farm-stored grains in relation to insect infestation thereof, made in 1938, resulted in the publication in October of that year of Farmers' Bulletin 1811, Control of Insects Attacking Grain in Farm Storage. It contains directions for the simple fumigation of such grains under farm conditions, together with directions for the proper farm storage of such grains. A survey was made of ripening grains in various parts of Kansas, Missouri, Oklahoma, and Texas to determine to what extent these grains became infested by insect pests of stored grain prior to harvest. As a result, 21 different species of insects were reared from wheat heads gathered in the States mentioned. In southwestern Missouri the rice weevil was found infesting corn in 50 percent of the cornfields examined, but in Kansas only a few widely scattered fields were found to be infested. Surveys indicated that losses in farm-stored grain would be much heavier in 1938 than for some years previous.

The somewhat general use of chloropicrin gas for the fumigation of grain in storage had raised the question of the possible unfavorable effect of such fumigation on the germination of wheat. A recent investigation of this subject has shown that the viability of wheat containing 14 to 16 percent of moisture is seriously injured when exposed to a dosage of 6 pounds of chloropicrin to 1,000 bushels of

grain for a period of 6 hours at a temperature of 95° F. However, at a temperature of 50° F. wheats containing any normal degree of moisture can safely be fumigated with chloropicrin at dosages of from 1 to 6 pounds to 1,000 bushels of grain for periods not exceeding 12 hours.

Observations during the year have shown methyl bromide to have considerable promise as a cheap and efficient fumigant for flour mills and stored rice. A recent fumigation of a large warehouse containing 3,500,000 pounds of rice with methyl bromide at a dosage of 4.85 pounds to 1,000 pounds of rice gave a complete kill of the contained insect pests within a period of 42 hours at a temperature of 87° F.

WHITE-FRINGED BEETLE CONTROL AND ERADICATION

Observations on the results of control and eradication measures applied against the white-fringed beetle (*Pantomorus leucoloma* (Boh.)) and a closely related species, *P. peregrinus* (Buch.), indicate the effectiveness, as a means of reduction in beetle population, of calcium arsenate dust on host plants, of an oil-base emulsion as an herbicide to eliminate host vegetation along railroad rights-of-way, roadsides, abandoned fields, and waste areas, and of clean-cultivation practices in crop areas.

Such practices, which were an important part of the 1938 program, were continued and their application was extended so that one or a combination of such methods of control was used on all known infested properties. While there has not been sufficient time to fully determine the effectiveness of such types of control, field observations indicate drastic reduction in beetle population, though to a somewhat lesser degree in fields where legumes were planted and where cryolite was substituted for calcium arsenate, because of the detrimental effect of the latter insecticide on such plants. During the latter part of the year excessive precipitation made the application of control measures difficult.

One of the important phases of the program designed to prevent the spread of the pest was the enactment of a Federal domestic plant quarantine effective January 1, 1939. The regulations were strictly enforced. This quarantine is supplemented by State quarantine measures which place restrictions on intrastate movement of host materials. Intensive surveys were conducted to delimit known infested areas and to determine whether the pest had spread to other parts of the infested States and to other Southern States. No infestations were found in any State in which the beetle had not been previously known to exist. During the year infestations were found in the following areas:

Alabama: Covington, Geneva, Monroe, Conecuh, Mobile, and Wilcox Counties.
Florida: Okaloosa, Walton, and Escambia Counties.
Louisiana: St. Bernard, Orleans, Jefferson, East Baton Rouge, Plaquemines, and Jeff Davis Parishes.
Mississippi: Jones, Harrison, Stone, Smith, Covington, Jackson, Hinds, Pearl River, and Forrest Counties.

The total infested areas comprise approximately 50,000 acres, a large portion of which is idle, forest, waste, or abandoned land.

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Full cooperation was given by the affected States in applying measures designed to control, eradicate, and prevent the spread of the white-fringed beetle. Local W. P. A. projects assisted materially in control operations.

MORMON CRICKET CONTROL

In cooperation with the States of Colorado, Idaho, Montana, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming, Mormon cricket control has been carried on with funds allotted to the Bureau from appropriations granted to the Department for the control of emergency outbreaks of insect pests and plant diseases. In addition to funds and personnel furnished by the States, substantial assistance was rendered by other Federal agencies and by many counties and communities in the infested States.

During the summer and early fall adult and egg surveys were conducted in the affected area to determine the intensity and extent of infestation as a basis for estimating probable control needs during the following crop season. More than 18 million acres were found to be infested, almost one-third of which were moderately or heavily infested, a considerable area being in the vicinity of valuable crops.

A cooperative plan of operations was developed under which participating States agreed to furnish technical assistance, transportation and living quarters for laborers, local hauling, storage, mixing plants, new dusting equipment and repairs, barrier metal, and motive power for dusters. The Bureau agreed to maintain field headquarters for the project, a project leader, supervision and administration, an adequate supervisory staff to plan, supervise, and direct control operations, and to provide oil, dust materials, power-duster operators, and warehouse facilities. Subsequent to agreement on these general principles, counties and communities were consulted and cooperative programs worked out with them. Various Federal agencies, including the Indian Service, the Forest Service, the Soil Conservation Service, and the Civilian Conservation Corps, cooperated in the program.

The plan of operations was based fundamentally on crop protection with latitude to permit work on areas distant from crops when danger of migrations from such areas to crop lands seemed likely, and also for work on areas where eradication appeared to be possible.

Crickets first appeared about mid-March, and early in April control work was well under way. Late in May and through June, operations were in full sway, with a peak of labor employment of more than 850 by the middle of June.

Sodium arsenite dust was most effectively used on the crickets by power, hand, and airplane dusters. Metal barrier, with pit traps, prevented crickets from entering crops, and an oil-on-water barrier was employed to kill the pests when they attempted to cross streams or ditches. Extensive field tests were conducted with a bait similar to that used for grasshoppers but consisting of sawdust, bran, and sodium fluosilicate. This material offers good promise, particularly where crickets and grasshoppers occur together, where crickets are

sparse and dusting control is impractical, or even in areas of heavy population.

At the end of the year more than 230,000 acres had been dusted with over 1,100,000 pounds of dust; more than 10,000 acres had been baited; metal barrier had been set up for more than 300 miles; and over 75,000 gallons of oil had been used on 425 miles of streams and ditches.

GRASSHOPPER CONTROL

Grasshopper control has been carried on under Federal funds appropriated for the control of incipient and emergency outbreaks of insect pests and plant diseases in cooperation with 24 Western States and with the aid of other Federal agencies, including the Civilian Conservation Corps, the Soil Conservation Service, the Forest Service, the Indian Service, the Agriculture Adjustment Administration, the Biological Survey, and the Federal Crop Insurance Corporation.

During the early part of the year control operations for the 1938 crop season were concluded. The infestation had been heavy and widespread, affecting all States but one west of the Mississippi River, as well as Illinois, Michigan, and Wisconsin. The success of the campaign was indicated by estimates, compiled by the States, of crop savings in excess of $176,000,000, or $79 worth of crops saved for each dollar spent on control.

During the late summer and early fall of the 1938 crop season an adult grasshopper and egg survey was conducted to determine the probable extent and degree of infestation to be expected during the subsequent season. Extensive, heavy concentrations of eggs were found in large areas in the Great Plains and Rocky Mountain States, extending from Texas to Minnesota, inclusive, and less extensive areas in other Western States. From this information estimates were made of the probable quantities of bait materials needed for control in the following spring and summer.

The surveys revealed heavy concentrations of eggs of two migratory species of grasshoppers in the northern and southern Great Plains States. In the Dakotas, Montana, and Wyoming eggs of the lesser migratory grasshopper were found over broad areas of sparsely populated idle and abandoned land in sufficient numbers to develop a serious outbreak unless natural control interfered. In southeastern Colorado, northeastern New Mexico, the panhandles of Texas and Oklahoma, and in a few counties in southwestern Kansas eggs of the long-winged migratory grasshopper (*Dissosteira longipennis* (Thos.)) were observed in heavy concentration on range land. Widely distributed over the Great Plains and intermingled with the migratory species, relatively heavy concentrations of eggs of nonmigratory species were found.

The threatening outbreak of migratory species necessitated an expansion of the control program to provide for direct participation, by the Bureau and the States, in mixing and applying bait in sparsely settled areas where heavy egg concentrations were found on idle, abandoned, and range land. In areas where eggs of nonmigratory species were dominant or where migratory species were less prevalent, the former policy of purchasing, transporting, and delivering bait materials to county mixing stations for spreading by farmers for pro-

tection of their own crops, under supervision of Federal and State supervisors, was considered adequate.

With a carry-over of more than 50,000 tons of bait materials, supplemented by late-winter purchases and the construction of thousands of additional mechanical spreaders, including more than 1,000 Federal machines, the cooperating agencies were prepared for the unusually early and uniform hatch of grasshoppers. As the season advanced, the outbreak predictions based on the egg survey were substantiated as conservatively accurate.

With adequate bait on hand at mixing stations to meet farmer demands for crop protection, the cooperating agencies swung rapidly into action on idle, abandoned, and range land. Farmer and community cooperation continued at a high peak until harvest diverted their attention.

In the area of the long-winged migratory grasshopper it became evident as the season advanced that excellent control was being obtained, and shortly after the close of the fiscal year operations were curtailed because of reduction in populations to not more than two or three grasshoppers per square yard. Plans were made to bait egg-bed concentrations later.

In the area of the lesser migratory grasshopper, enormous quantities of bait materials were distributed, particularly in Montana and North Dakota. Although at the height of the season it appeared that destructive migrations might develop from the enormous acreage of high populations, there were no mass, long-distance, destructive flights such as occurred in 1938, and while severe crop damage occurred in limited areas, it did not compare with the vast acreage of good crops protected.

At the close of the fiscal year more than 235,000 tons of bait had been made available to the States. To the following States the approximate amounts indicated had been shipped: North Dakota, 47,000 tons; Montana, 35,000; Minnesota, 25,000; Colorado, 25,000; South Dakota, 21,000. Other States received lesser amounts as needed.

During the season tests were conducted to determine the practicability of spreading bait from airplanes. Thirteen planes were leased and tested in areas of heavy populations, and present indications are that, while further work is needed on bait hoppers and spreading mechanisms, spreading of bait for grasshoppers by planes is a valuable adjunct to the control program, especially in idle lands and areas difficult of access by ground crews.

While it is yet too early to predict the amount of crop savings attributable to grasshopper control for the year, there is conclusive evidence that economic protection to crops has been given in spite of the unprecedented outbreak.

EUROPEAN CORN BORER INSPECTION AND CERTIFICATION

In the European corn borer certification work there was a considerable spurt in inspection activities to comply with the State quarantines of Arizona, California, Colorado, Georgia, Louisiana, Nevada, Oregon, Texas, and Utah. Inspection services were available through the gypsy moth and Japanese beetle inspection corps,

as well as through the corn borer inspectors in Detroit and Indianapolis.

A total of 50,190 certificates were issued to cover quarantined plant material valued at $157,000. This represented a 134-percent increase in the number of certificates over the preceding fiscal year but a 21-percent decrease in the value of the certified products. The increase in certifications was due to larger shipments of dahlias, gladioli, and chrysanthemums from Virginia, Maryland, New York, and Ohio.

BARBERRY ERADICATION

State, county, and local agencies in 17 grain-growing States continued active participation in the barberry-eradication program for the control of stem rust of cereals during the year. Stem rust is one of the most destructive diseases that attack grain crops, and control measures are applied uniformly on a regional rather than a State basis. Wherever barberry bushes susceptible to attack by the rust fungus are permitted to grow in or adjacent to important grain-growing areas they serve as early sources of inoculum that may cause local epidemics of the disease. In areas where bushes are numerous these local outbreaks often coalesce to form destructive regional epidemics before crops mature.

The annual rust survey was further systematized and extended to include observations in Mexico. The intensive search for barberry bushes, conducted with relief labor closely supervised by experienced Bureau personnel, was continued in counties that had not already been covered. Marked improvements were made both in survey and chemical-eradication procedures. Field demonstrations were held to instruct grain growers in the nature of the disease, the identification of barberry bushes, and recommended control practices.

BARBERRY BUSHES DESTROYED IN 221 COUNTIES

Barberry bushes were eradicated in 221 counties in the 17 participating States. With the aid of relief labor an intensive survey was made of all planted shrubbery, native timber, and other uncultivated lands in an area comprising more than 51,600 square miles. This resulted in the eradication of more than 1,930,340 bushes on 1,971 properties in the 13 States—Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming—which comprised the original control area, and 45,514,880 bushes in Missouri, Pennsylvania, Virginia, and West Virginia, where organized control work was not undertaken until 1935. Forty-three million, three hundred and eighty-eight thousand of these were of the species *Berberis canadensis*, which is native to Virginia and West Virginia but occurs only in very limited areas in States farther north.

PRESENT STATUS OF CONTROL WORK

The status of the eradication program varies considerably in different States within the control area and in different areas within individual States. In Montana, Wyoming, North Dakota, South Dakota, and parts of Colorado and Nebraska the initial eradication

work has been completed, and plans have been outlined to prevent reinfestation in those areas where barberry seed was distributed by natural agencies before the original bushes were destroyed.

In Iowa and in States east of the Mississippi River, where infested areas exist in far greater numbers, many of them involving all uncultivated land in entire counties, the status of the program is not so far advanced. In Iowa, Wisconsin, Illinois, Missouri, Minnesota, Indiana, Ohio, and Michigan an intensive survey has been made of about 60 percent of the counties needing attention. In these States, as in those farther west, detailed records, including maps, have been kept of all locations where barberry bushes were found, thus simplifying reinspections of infested areas.

In Pennsylvania, Virginia, and West Virginia field operations have been restricted to the more important grain-growing valleys, and striking results have been obtained in localized areas where bushes have been removed. These States are not subject to the sweeping winds that frequently distribute spores for great distances in the Great Plains region, and whenever bushes are destroyed there is a marked reduction in the amount of rust that occurs the following year.

Table 9 summarizes, by States, progress in barberry eradication during the year.

TABLE 9.—*Progress in barberry eradication by States, fiscal year 1939*

State	Counties surveyed	Area surveyed	Properties cleared of bushes	Barberry bushes destroyed	Salt used
	Number	*Square miles*	*Number*	*Number*	*Tons*
Colorado	5	873	81	1,752,674	48.91
Illinois	13	7,044	237	2,481	8.04
Indiana	30	4,300	131	9,834	5.71
Iowa	26	5,488	260	3,460	26.34
Michigan	16	1,674	473	78,888	56.68
Minnesota	20	5,027	203	7,513	27.58
Montana	3	1,200	15	2,716	1.64
Nebraska	18	6,700	33	112	.39
North Dakota	6	2,309	8	1,000	.37
Ohio	23	5,524	227	34,302	13.87
South Dakota	5	5,510	4	31	0
Wisconsin	15	1,499	299	37,332	28.85
Wyoming	5	252	0	0	0
Total	185	47,400	1,971	1,930,343	218.38
Missouri	7	1,312	46	1,220	.98
Pennsylvania	10	2,398	1,453	2,125,021	434.97
Virginia	12	236	420	16,373,150	1,028.01
West Virginia	7	290	258	27,015,489	1,060.69
Total	36	4,236	2,177	45,514,880	2,524.65
Grand total	221	51,636	4,148	47,445,223	2,743.03

RUST-SUSCEPTIBLE BARBERRY BUSHES EXCLUDED FROM INTERSTATE TRADE BY FEDERAL QUARANTINE

The object of Quarantine 38 (revised) is to prevent, through education and regulation, the interstate movement (into or between States comprising the protected area) of rust-susceptible species of barberry. During the spring of 1938, 47 nurserymen planning interstate shipment of immune species of *Berberis* and *Mahonia* (other than *B. thunbergii*) applied to the Bureau for the necessary Federal permits.

As a result of the inspection of 11,400 acres of nursery stock, 23,750 rust-susceptible barberry bushes were destroyed. Forty nurseries were found to meet quarantine requirements, and interstate shipping permits were granted. Two failed to qualify, 2 required no permits, and no action was taken in regard to 3 nurseries where further clean-up work is necessary.

A year ago a review of nursery catalogs on file in the Department of Agriculture Library indicated that about 40 nurseries (all outside the quarantined area) were advertising susceptible species of barberry for sale. This number has now been reduced to about 30, and it is expected that within a very few years practically all nurseries will have discontinued the sale of other than immune species.

Again this year all available species of barberry not definitely classified with respect to their reaction to the stem-rust fungus were inoculated under natural conditions. There are known to be more than 150 different species of barberry in the United States, most of which have been introduced from foreign countries. Of this number, only 32 are immune to attack by the stem-rust fungus.

STEM RUST PREVALENT OVER LARGE AREA IN 1938

Again in 1938 stem rust of small grains became epidemic over extensive areas from Texas to the Canadian border. However, owing to the predominance of the rust-resistant Thatcher wheat in Minnesota and certain sections of North Dakota and hot, dry weather that checked the development of the fungus and matured crops prematurely in South Dakota and certain parts of North Dakota, rust losses in the spring wheat area this year were not nearly so great as in 1935 or 1937.

A discussion of the factors contributing to the epidemic of 1938 must include some mention of rust observations made in the fall of 1937. Stem rust was prevalent on late oats, volunteer grains, and certain native grasses, particularly wild barley (*Hordeum jubatum*) in southern Minnesota, Iowa, and northern Missouri in August 1937. There is evidence that from here rust spores were blown southward early in the fall, for infection was found on volunteer oats near Guthrie, Okla., on October 24, and at several points in Oklahoma and Kansas a month later. There is little doubt that fall-sown grains in Texas and northern Mexico became infected late in the season and that the rust survived the winter of 1938–39 in the uredial or spreading stage.

To determine, if possible, the extent to which rust in Mexico contributed to the development of the disease later in the season in Texas and States farther north, a rust survey, conducted in cooperation with representatives of the Instituto Biotecnico, Mexican Department of Agriculture, was made in February, and again in April, of the more important grain-growing areas in Mexico.

Specimens of rusted grain were obtained from representative localities within each geographical area and studies made to determine the particular races of the fungus that were present. Southern Mexico apparently did not contribute to the epidemic in the United States in 1938, nor could it have furnished all the inoculum for northern Mexico. With the exception of one collection of race 24, only races 59 and 38 were identified from specimens obtained in southern Mexico in 1938.

In this area Marquis wheat, which is extremely susceptible to races of stem rust now prevalent in the spring wheat area of the United States, has been grown for several years because of its rust resistance. It is significant, therefore, that Marquis is not susceptible to the races of rust that were identified from rusted grains collected in southern Mexico. Of the nine different races found in northern Mexico, all were subsequently found in the United States.

CONDITIONS FAVORED NORTHWARD MOVEMENT OF RUST IN 1938

Stem rust was first observed in Texas in the spring of 1938 on February 2 at College Station. It was later determined that a scattering of rust had appeared in San Antonio and other sections of southern and central Texas at about the same time. Near San Antonio there was considerable early grain, and, as a result of excessive rainfall, rust became abundant fairly early in the season.

During the period May 3 to 5, and again on May 17 and 18, south winds are believed to have been responsible for spore showers in Oklahoma, Kansas, Missouri, and western Illinois. On June 5 spores were trapped as far north as Fargo, N. Dak., and on June 15 infection was observed on wheat in west-central Minnesota and at Brookings, S. Dak. While there was considerable variation in the amount of rust that developed in different localities in Kansas, Missouri, and Nebraska, this area produced an abundance of inoculum which appears to have contributed materially to the epidemic that developed later in States farther north. By exposing spore traps daily at certain representative points throughout the Mississippi River Valley it was possible to determine just when spore showers occurred.

Table 10 shows the estimated number of spores trapped at representative points in the Great Plains region during 24-hour periods on the dates indicated.

TABLE 10.—*Estimated numbers of spores trapped at representative points in the Great Plains region, 1938*

Place	May 16	May 18	May 24	May 25	June 13	June 14
Oklahoma City, Okla	1,296	432	96	6,192	92,864	86,352
Beatrice, Nebr	672	3,382	1,440	528	37,296	17,040
Dallas, Tex			95,616	33,600	3,648	13,056
Madison, Wis			192	0		
St. Paul, Minn					26,688	5,568
Ames, Iowa					18,480	2,880
Brookings, S. Dak					10,800	1,824
Fargo, N. Dak					1,248	96

There was a period from May 16 to 25, inclusive, when conditions favored the northward movement of rust. Again, on June 13 and 14, south winds carried an abundance of inoculum into Northern States. Unlike the epidemic in 1937, when rust spreading from the South reached into Illinois, Indiana, and even western Ohio, the epidemic this year moved more in a northwesterly direction, eventually causing considerable damage as far west as eastern Montana.

Although more than 160 physiologic races of the stem-rust fungus have been identified during the past 15 years, race 56 was primarily

responsible for the epidemic in 1938. It was isolated from 85 percent of all the collections of rusted grains and grasses obtained in the United States and was the most prevalent form for the fifth consecutive year. Never before, since the physiologic-race survey was undertaken on an extensive scale, has any single race of rust been so predominant. While 4 other races (38, 19, 17, and 11) were rather widely distributed, varieties of grain resistant to race 56 in general escaped serious rust damage.

BARBERRY BUSHES RUSTED HEAVILY IN 1938

Before rust appeared on grains in southern Oklahoma barberry bushes in the Northern States were becoming infected. Both the pycnial and aecial stages of the fungus were observed on barberries in Missouri by May 5, in Illinois by April 20, in Iowa and Nebraska by April 29, in South Dakota by May 27, in Minnesota by May 6, and in North Dakota by June 6. Rust was spreading from barberry bushes to nearby grains and grasses in these States 4 to 6 weeks before infection became general on grain away from known bushes.

Further evidence was obtained in 1938 to indicate that new hybrid races of the stem-rust fungus may be produced at the time infection occurs on the leaves of the barberry. These hybrid races may prove capable of attacking new and improved varieties of grain that have been tested and found resistant to both parent races of the fungus.

In 1938, as in previous years, many instances were encountered in which local epidemics of stem rust could be traced directly to the barberry bushes that were responsible for the initial inoculum.

FIELD DEMONSTRATIONS CONDUCTED FOR EDUCATIONAL PURPOSES

Educational work in connection with the barberry-eradication program in recent years has been conducted largely to stimulate the interest of property owners in keeping their lands free of barberry bushes once the initial eradication work has been completed. Frequently it has been possible, in cooperation with county extension agents and representatives of State departments of agriculture, to arrange field demonstrations where farmers and local businessmen could observe the damage caused by a few barberry bushes so situated as to spread rust directly to grain crops. Such demonstrations held in Iowa, Minnesota, Wisconsin, and Pennsylvania have created much interest in the objectives of the regional program. Each demonstration has been held just at the time that fan-shaped spreadings of rust could be traced directly to the bushes serving as the source of inoculum. Similar demonstrations of actual eradication of barberry bushes, to show farmers how much chemical is required to kill bushes and the proper methods of applying it, were held in several States.

Again this year information concerning the development and spread of stem rust was submitted to the Department Press Service weekly during the growing season. More detailed reports were made available at frequent intervals to various units of the Department interested in current crop conditions.

TRUCK CROP AND GARDEN INSECT INVESTIGATIONS

TOMATO FRUITWORM

In the summer and fall of 1938 the investigations on the tomato fruitworm were continued on a comparatively large scale in California, Utah, and southern Indiana, and the following discussion applies to the results obtained during that period. During the course of these investigations a series of experimental tests were performed with materials containing rotenone, particularly derris and cube, and with phenothiazine, cuprous cyanide, copper arsenate, copper cyanamide, cryolite, calcium arsenate, and several other materials. All these insecticides, except those containing rotenone, were of some value in reducing injury done by the tomato fruitworm, but cryolite and calcium arsenate gave the best results. While the degree of crop protection attained by using cryolite and calcium arsenate in dust mixtures, spray mixtures, and poisoned baits varied considerably in different seasons and on different farms, the indications were that the best yield of uninjured fruit was obtained when a cryolite-dust mixture containing 70 parts by weight of cryolite and 30 parts of talc was used. In these tests natural cryolite which contained approximately 90 percent of sodium fluoaluminate and one brand of synthetic cryolite containing approximately 98 percent and another containing approximately 83 percent of sodium fluoaluminate were employed. In replicated experiments on several varieties of tomatoes and in several different fields the application of the cryolite-dust mixtures resulted in a degree of control which ranged from 30 to 90 percent. These figures are based on the percentage of fruits damaged by the fruitworm in treated plots as compared with the percentage damaged in plots that were either dusted with a cube dust mixture or left undusted. Some of the check plots in the fields where these experiments were performed were threatened by the tomato pinworm, and in order to prevent serious loss to the grower from this source applications of cube dust were made, as this material was known to be partly effective against this insect, but would not affect the tomato fruitworm; consequently the application of these cube dusts did not seriously affect the results of insecticidal tests against the tomato fruitworm. Three brands of calcium arsenate were used and these gave control ranging from 30 to 64 percent on the same basis of comparison as stated previously. It will be noted, therefore, that calcium arsenate was slightly inferior to cryolite although in laboratory tests it appeared that the former material was as toxic to quarter-grown larvae of the fruitworm as was cryolite.

The highest degree of tomato fruitworm control was achieved with cryolite-dust mixtures when three applications were made at 2-week intervals, beginning when the foliage of the tomato plant was about 1 foot in diameter. In California, where on an average an acre of tomatoes contained 1,000 plants, approximately 10 pounds of the dust mixtures was used for the first application, 20 for the second, and 30 for the third, per acre. Both power dusters and fan-type hand dusters were used to apply the materials, and the plants were dusted from both sides at each application. A special attempt was made to cover all the foliage, since extensive biological observations have

demonstrated that the eggs are deposited principally on the upper and lower surfaces of the tomato leaves around the periphery of the plant.

A poisoned bait prepared by mixing thoroughly 1 pound of cryolite and 10 pounds of bran with 1 quart of corn oil was nearly as effective as the cryolite-dust mixture. The bait was applied by hand and an attempt made to scatter the material lightly and evenly over the leaves of the entire plant. Three applications were made at the same time and same time intervals as were employed with the dust mixtures. Approximately 40 pounds of the bait was used per acre for each of the first two applications and from 60 to 70 pounds for the third application.

Although several baits containing different poisons, mixed with corn meal, or with bran and corn oil, were tried in one field with rather poor results, research on these baits will be continued, since the cost of these materials per acre is approximately the same as for the dust mixtures, and growers appreciate the ease and speed of application without the use of special equipment. The indifferent control obtained with these baits may be attributable to an uneven rate of crop development in the field where they were tested, since the results were contrary to those recorded in the corresponding period of 1937. It has been found, however, that since corn meal, bran, and sawdust vary greatly in weight per unit of volume, it will be necessary to vary the composition of poisoned baits containing each of these materials to compensate for their variation in density. In general the sawdust baits are much lighter per unit of volume than those containing corn meal or bran.

Sprays containing cryolite diluted at the rate of 8 pounds to 100 gallons of water plus a sticking or wetting agent gave a fairly effective degree of control of the fruitworm. Although the results obtained with a dust mixture containing 40 percent of phenothiazine were rather unsatisfactory, the indications were that this material has possibilities as an insecticide for combating the tomato fruitworm if a suitable sticker can be found to make it adhere to the plants. Cuprous cyanide gave comparatively poor results against the tomato fruitworm, and copper cyanamide gave only fair control.

Laboratory tests in southern California showed that hydrated lime was safer than talc for use as a diluent for paris green on tomato foliage. It was shown also that mixtures of cryolite and calcium arsenate with talc (50–30–20) might cause some degree of burning to the tomato plant, but additional tests are necessary to obtain final information on this point. The latter combination, if it could be used safely by the growers, would have a distinct field of usefulness as a threefold insecticide for the control of the tomato fruitworm, the tomato pinworm, and the species of hornworms (*Protoparce sexta* (Johan.) and *P. quinquemaculata* (Haw.)) ordinarily found on tomatoes. These tests showed further that a poisoned-bait mixture consisting of 25 pounds of corn meal and 1 pound of a calcium salt of dinitrocyclohexylphenol was apparently not safe to use on tomato foliage, whereas a poisoned-bait mixture consisting of 25 pounds of corn meal and 1 pound of paris green injured the tomato foliage, but was rendered safe for this purpose by the addition of 1 pound of hydrated lime to the formula.

An interesting and important point learned during the progress of biological studies was that newly hatched larvae of the tomato fruitworm, in crawling over the foliage of tomatoes that had been treated with insecticides, picked up particles of such insecticides with their mandibles and also cleaned off their feet by drawing them through the oral aperture, indicating that these larvae may be poisoned by insecticides without actually devouring the treated foliage or fruit.

The sparse infestations of the tomato fruitworm in northern Utah following a mild winter and a 16-percent survival of pupae in overwintering cage experiments emphasized the importance of the movement or migration of the moths from the South and verified the conclusion of various workers in Ohio, Illinois, and Indiana that the source of the infestations of the tomato fruitworm in northern latitudes is ordinarily the migration or movement of adults from the southern part of the country. Experiments with 17 different insecticides and toxicity tests with a bait and a dust mixture which were applied in 22 different combinations of time of season, interval between applications, and number of applications throughout the period between July 11 and September 12 were handicapped because the sparse infestation would not permit significant conclusions to be drawn on the relative efficiency of the different insecticides or treatments.

Owing to the sparse infestation of the tomato fruitworm in southern Indiana, the experiments at that point did not yield significant results regarding the relative efficiency of the different insecticides used.

The results of residue studies in California and Indiana led to the conclusion that none of the insecticidal materials used in the control of the tomato fruitworm which are likely to leave a poisonous residue on the harvested fruits should be applied within 3 weeks of the first picking. Preliminary studies indicated that if no applications are made within this 3-week period no excessive residue is likely to be present on the harvested product. In instances where a residue does occur on the fruit at harvest time, the indications are that the washing process in the cannery or the wiping of the fruit with a cloth or similar process preparatory to its marketing will practically eliminate the residue.

TOMATO PINWORM

Although the tomato pinworm continued to cause severe losses to the tomato crop in some fields of southern California during the summer and fall of 1938, such losses were not so pronounced as in previous years except in certain districts where tomatoes are grown in a succession of plantings throughout the frost-free period. Much of the improvement in the tomato pinworm situation is attributed to the activities of the growers who followed the recommendations of the Department by cleaning up and destroying tomato-crop remnants, which ordinarily function as important sources of reinfestation, and then giving the infested fields a clean plowing. This development has corroborated the experimental evidence obtained by the workers to the effect that the elimination of infested tomato-crop remnants comprised a very important item in pinworm control.

The results of extensive tests with various insecticides, involving a total of 330 field plots, corroborated previously obtained information

to the effect that cryolite and cuprous cyanide, in either sprays or dust mixtures, were the most effective stomach poisons available for use against this pest. It was found, however, that although these materials give satisfactory control of the pinworms up to the time of the early picking of the tomatoes, the degree of control ranging from 85 to 90 percent, the numerical abundance of the pest increases so rapidly when climatic conditions are favorable that 1 or 2 applications of insecticides toward the end of the picking season may be required in the presence of intense infestation as a final step in pinworm control. Ordinarily, however, 3 or 4 applications of cryolite or of cuprous cyanide appear to be sufficient to control the pinworm if they are timed properly.

The tests of 1938 disclosed that materials such as phenothiazine, cube, and derris are of doubtful value in combating the pinworm.

Biological investigations of the pinworm disclosed that in southern California the conditions prevailing during the winter have an important relation to the survival of the species, since temperatures below freezing increase greatly the rate of mortality, but that the prevalence of wet and cool weather during the spring and early summer may have such a detrimental effect on the survival of the pinworm moths and their rate of egg deposition as to counteract favorable winter conditions.

During the past two or three seasons parasites have become an important natural influence in checking the abundance of the pinworm. Two species new to science as well as two species not previously known to exist in southern California have acted as checks.

PEA WEEVIL

Extensive field experiments in controlling the pea weevil, carried on in cooperation with the States of Washington, Oregon, and Idaho during the year, again demonstrated that dust mixtures containing rotenone will protect peas against this pest if the mixtures are applied in the way recommended and at the proper time.

Special surveys in the Blue Mountain area of Washington and Oregon revealed that over four times as much dust mixture containing rotenone was used against the pea weevil in this area as was used the preceding season. In 1937 approximately 47.5 tons of dust mixtures containing rotenone, costing approximately $10,925, was used to protect peas (about 38,000 acres), whereas in 1938, with an area of approximately 34,000 acres in peas, 211.5 tons of dust mixtures containing rotenone, costing approximately $37,780, was used. The general results of the control campaigns were nearly the same, since 716 acres of peas, constituting 1.9 percent of the total acreage, were discarded in 1937 on account of pea weevil damage, whereas in 1938 the area discarded was 386 acres, or 1.1 percent of the total acreage. The decided success attained against the pea weevil during preceding seasons by the use of dust mixtures containing rotenone led to a further intensification and increased use of this materal during the spring and early summer of 1939. As illustrating the extensive use of this insecticide it may be stated that one canning company in Washington used approximately 150,000 pounds of the dust mixture costing about $6,000. Moreover, some of the larger canning companies have adopted the policy of preparing their own dust mixtures rather than purchasing commer-

cial mixtures. In preparing these dust mixtures very elaborate precautions have been taken by the growers to insure that the product, when ready for application, has the recommended rotenone content of approximately 1 percent.

In many districts of the pea weevil-infested areas of Idaho, Washington, and Oregon an innovation in entomological procedure has developed in that the growers of peas have voluntarily examined their fields repeatedly to determine what portions of the fields are infested by the pea weevil to such an extent as to warrant the application of insecticides. As a result of their experiences during the past two or three seasons many of these growers have become adept in examining their fields and in recognizing the presence of a potentially destructive pea weevil infestation. Some of the larger canning companies have employed full-time entomologists to aid in the pea weevil-control program, while others have employed trained personnel for that part of the season when technical knowledge is needed.

An outstanding accomplishment in the control activities against the pea weevil has been the development of large units of dusting equipment. Many of these units are equipped with a 50-foot boom, and during the early season of 1939 one outfit with an 80-foot boom which distributes the dust mixture uniformly throughout the entire 80-foot swath was developed by private interests. This particular unit has a hopper capacity of approximately 800 pounds of the rotenone-dust mixture and is capable of dusting approximately 250 acres per day. The use of these dusting units has led to a question regarding the extent of mechanical damage caused by their passage through the pea fields. To answer this question, a study was made in 29 typical pea fields in Washington. The resulting data indicate that dusters with a 30-foot swath pulled by caterpillar tractors with 8-inch treads caused sufficient damage to decrease the yield by about 5 percent as compared with that in fields not treated with insecticides. Horse-drawn dusters caused half or less than half this damage, and the 30-foot dusters pulled by trucks caused a decreased yield of approximately 3 percent. Although no detailed studies have been made regarding the degree of mechanical damage caused by the 50-foot or 80-foot dusters, the fact that the use of these larger units decreases the number of trips in any field has led to the general conclusion that they cause less damage than the smaller units. The comparatively small degree of mechanical damage caused by the dusting units is not held by the growers to be important in comparison with the excellent control of the pea weevil obtained by their use.

Tests in the laboratory and in the field indicated that the effectiveness against the pea weevil of dust mixtures containing rotenone was not increased by the addition of various conditioners. In general the mixtures containing 1.0 percent of rotenone were more effective than those containing 0.75 or 0.50 percent. Much less difference was noted in the toxicity to the pea weevil between dusts containing 1.0 and 0.75 percent of rotenone than between those containing 0.75 and 0.50 percent of this ingredient, particularly in tests made during the spring. These results agree in general with the limited field trials with dusts containing these percentages of rotenone. A cube-dust mixture with diatomaceous earth as a carrier did not give so high a degree of mortality of the pea weevil as cube with talc as a carrier, particularly

at the higher dosages. Near the median lethal dosage, however, there were no significant differences between the performance of these two diluents. The addition of 2.0 percent of peanut oil, 1.0 percent of sodium oleyl sulfate, and 0.5 percent of water to cube in a dust mixture with talc as a diluent did not increase the toxicity of the material as compared with a cube-talc dust mixture not containing these conditioners. A dust mixture containing 0.005 percent of sulfur nitride was nontoxic to the weevils. The addition of 0.225 percent of total pyrethrins to the cube-dust mixture with talc as a diluent, containing 0.5 percent of rotenone, markedly increased the toxicity of the resulting dust mixture to the pea weevil. During the course of these experiments it was determined that the weevils which recover from the paralysis induced by sublethal dosages of rotenone were capable of oviposition, but whether these eggs were viable was not learned. It was also disclosed that the weevils which developed during the summer were much more resistant to dusts containing rotenone than those that had been kept in storage from fall until the following spring.

As a corollary to these insecticide tests, additional data were accumulated which indicate that the toxic effect of dust mixtures containing rotenone to the pea weevil is attributable principally to the contact properties of the active ingredients, but also to the action of these ingredients as a stomach poison.

Hibernation studies following the mild winter of 1937–38 disclosed that pea weevils were able to overwinter successfully in grass, grain, weeds, weeds and straw, grain and weeds, pea-harvest debris, wheat stubble, duff from deciduous bushes, and debris from pine trees. This newly discovered information explains the presence of the weevils in areas remote from the preferred hibernation quarters in dense growths of pine and indicates the possibility of devising methods for destroying part of the pea weevil population during its overwintering period.

Studies conducted in Oregon on the flight habits of the pea weevil with the aid of a rotary mechanical trap revealed that the magnitude of weevil flight is governed by three major factors—temperature, time of day, and season of the year. It was disclosed that the peak of flight activity occurred only when the temperatures reached 68° to 74° F. or higher and that these flights reached their daily peak late in the morning and early in the afternoon. The flight of the weevils is practically stopped when the daily maximum temperature fails to rise higher than 66° to 74°. In general the magnitude of daily flights was found to be correlated directly with daily maximum temperature. It required a higher range of temperature to stimulate the weevils to flight during the spring and summer than during the fall.

Although it has been shown definitely that the application of insecticides containing rotenone comprised a very effective control for the pea weevil, the annual summation of the data collected on infestations by this insect in the Palouse area of Washington and Idaho as obtained from the records of the pea-grading service of the Bureau of Agricultural Economics, cooperating with the Department of Agronomy of the University of Idaho, disclosed that on an average during 1938 approximately 12.5 percent of the dry peas examined

were found to be infested by the pea weevil. Five hundred and seventy-eight graded crops were examined. This is approximately five times the average pea weevil infestation in a comparable area during 1937 and indicates that the 1938 infestation of the pea weevil was one of the most severe on record. The marked increase appears to be attributable principally to a mild preceding winter that allowed a high rate of survival of adults and to a reduction of pea acreage in the Palouse area. This reduction apparently resulted in a higher degree of concentration of the weevil population on the relatively small area of peas available for oviposition.

Inquiries addressed by this Bureau to entomologists in New Jersey, New York, Indiana, Illinois, Michigan, and Wisconsin respecting the status of the pea weevil as a pest in those States elicited the information that in New Jersey, Indiana, Illinois, and Wisconsin the insect is ordinarily present in very limited numbers and cannot be considered an important pest. In New York and in Michigan, however, the State authorities assert that, although the pea weevil is not now abundant, serious damage has been caused by this pest in those States during the past years when peas were grown on a commercial scale by the dried-pea industry for use as seed or feed.

GLADIOLUS THRIPS

Extensive tests made during 1938 of various sprays to control the gladiolus thrips in the field and in the greenhouse led to a confirmation of the effectiveness of a tartar emetic-brown sugar spray for this purpose and its superiority to any other known insecticide. From these tests the following conclusions were reached: (1) Tartar emetic-brown sugar sprays, whether composed of 2, 3, or 4 pounds of tartar emetic and 8 or 16 pounds of brown sugar per 100 gallons of spray, were of practically equal efficiency. On plots sprayed with 2 pounds of tartar emetic there appeared to be less residual effect of the tartar emetic than where 4 pounds was used; hence the thrips caused more injury later in the flowering season on plots where the lower dilutions were used. No injury to gladiolus foliage resulted from the tartar emetic sprays, and the degree of control achieved was equal to that obtained with sprays containing paris green and brown sugar. (2) While a satisfactory degree of control was obtained with sprays containing 2 pounds of paris green and 64 pounds of brown sugar per 100 gallons of water, this spray caused moderate to severe foliage injury, the magnitude of which varied with the variety of gladiolus involved. (3) Sprays containing derris and peanut oil not only failed to give a satisfactory control of the gladiolus thrips, but made the normal green surface of the foliage oily, and dust covered and yellowed it. The plants sprayed with this combination were also stunted and retarded for more than a week in the development of their flower spikes. The plants treated with a derris root powder spray containing 0.02 percent of rotenone were more adversely affected by thrips and by the insecticide than those treated with a derris root spray containing 0.015 percent of rotenone, even though peanut oil was used at a concentration of 1 percent in both sprays. (4) A spray composed of derris root powder containing 0.015 percent of rotenone, with varnish as a sticker, plus a sodium sulfate of technical lauryl alcohol as a wetting agent, gave only partial control of the thrips. (5) A spray

containing tartar emetic alone at the rate of 4 pounds to 100 gallons of water gave no appreciable control of the thrips, demonstrating the necessity of using some type of sweet substance in the spray to obtain satisfactory results. In this connection no attempt has been made thus far to determine the comparative effectiveness of brown sugar and other easily available sweet substances that might be used in combination with tartar emetic as a spray for gladiolus thrips control. (6) A spray containing nicotine sulfate (1 to 500) with karaya gum (1 to 500) was also ineffective, as was tartar emetic, at a dilution of 4 pounds to 100 gallons of water with a commercially prepared sodium oleyl sulfate as a wetting agent.

In tests to determine the quantity of mercuric chloride (corrosive sublimate) that is absorbed by the gladiolus corms when they are soaked in a solution of this chemical in the spring to combat any thrips that may be resident thereon, it was found that from 37 to 69 percent of the chemical was removed from a 1 to 1,000 solution, in the presence of temperatures of 60° and 70° F., respectively, when the gladiolus corms, encased in burlap bags, were immersed in the liquid for a period of 17 hours. No significant differences could be detected between the results obtained at the two solution temperatures. Attempts to use the solutions for a second bath of corms, by recharging with approximately one-half the original quantity of the chemical, by weight, resulted in the production of solutions of varying strength which could not be relied upon to kill gladiolus thrips on the corms. It was concluded, therefore, that to obtain a satisfactory reaction from the mercuric chloride treatment a fresh solution should be prepared for each batch of corms to be treated.

RELATIVE VALUE OF VARIOUS INSECTICIDES IN COMBATING PESTS OF VEGETABLES, BERRIES, TOBACCO, AND ORNAMENTALS

During the progress of experiments to determine the identity and proper dilution of insecticide materials that would control certain of the pests attacking vegetables, berries, tobacco, and ornamentals and not leave harmful residues on the market product or injure the plant seriously, it has become apparent that some of these materials are characterized by specific responses, as disclosed by tests in the laboratory and in the field.

For example, it was found that pyrethrum is very effective against the celery leaf tier, whereas derris is noneffective, and lead arsenate and cryolite are not sufficiently effective against the half-grown or nearly full-grown stages, at the dilutions ordinarily considered practicable, to warrant the risk of residue hazard incurred by their use. On the other hand, comparable tests with these four insecticides showed that derris and pyrethrum were highly specific against all stages of the imported cabbage worm and much more effective than either lead arsenate or cryolite. These results emphasized that the organic insecticides enumerated could be used in controlling this important pest of cole crops without danger of harmful residue and that the other materials were not so suitable.

In experiments for controlling the southern armyworm it was found that to the insect at quarter-grown or larger stages either pyrethrum or derris was very nearly nontoxic, but that either cryolite or lead arsenate was specific against this widely distributed pest of many vegetable

crops in the South. Either pyrethrum or derris was effective against the newly hatched larvae of the southern armyworm, but the degree of efficiency decreased rapidly after the larvae had reached the quarter-grown stage.

In addition to being effective in combating the tomato fruitworm, tomato pinworm, southern armyworm, celery leaf tier, and imported cabbage worm, cryolite has given indications of being useful in combating hornworms on tobacco. For this purpose a dust mixture containing 80 percent of cryolite is used, or a spray is made with 6 pounds of cryolite containing 85 percent of active ingredients and 50 gallons of water. It appears that cryolite is not so likely to burn or discolor the plant or leave an objectionable residue on the harvested product as paris green or other arsenicals commonly employed.

Although during the season of 1937 cryolite was used successfully as a dip for tobacco plants prior to setting, to protect them from injury by the corn root webworm, a serious pest of tobacco in many districts, the work in 1938 did not verify the results of the previous year. Some indications were obtained that cryolite may be of value in the control of the tobacco flea beetle, the strawberry weevil, and the beet armyworm. When used as a spray or as a dust mixture cryolite has not proved so effective against the Mexican bean beetle as derris or cube, but it was more effective than either derris or cube in controlling the corn earworm on lima beans.

Because of its chemical composition, cryolite is difficult to apply as a dust mixture, and it seems essential that some carrier be used with it to improve its dusting qualities. The indications are that if a satisfactory degree of insect mortality is to be obtained with cryolite it must not be diluted more than 50 percent. Although in general the synthetic and natural forms of cryolite have been almost equally toxic when tested on properly replicated plots, there have been occasions when a commonly used domestic brand of synthetic cryolite seemed superior to a widely distributed imported brand of the synthetic material.

While insecticides containing rotenone derived from derris, cube, or devil's shoestring (*Tephrosia*) have proved effective against such insects as the Mexican bean beetle, imported cabbage worm, cabbage looper, diamondback moth, pea aphid, turnip aphid, pea weevil, raspberry fruitworm, tobacco flea beetle, common red spider, and certain species of thrips (*Thrips tabaci* Lind., *Heliothrips haemorrhoidalis* (Bouché), and *Taeniothrips xanthii* Williams) on greenhouse-grown cucumbers and tomatoes, they have not proved effective against the celery leaf tier, southern armyworm, tomato fruitworm, tomato pinworm, tomato and tobacco worms, zebra caterpillar, mole crickets (*Scapteriscus* spp.), sweetpotato weevil, cutworms, and leafhoppers. In general, derris and cube, when containing approximately the same total active ingredients, have given approximately the same degree of efficiency against any given insect.

In special tests it was shown that sprays containing lead arsenate were superior to sprays containing derris, phenothiazine, or sulfur nitride for the control of the Colorado potato beetle.

Some of the commercially prepared organic thiocyanates have given promising results against the more common species of mealybugs and the common red spider, although causing a variable degree of injury to some species of susceptible plants.

Solutions of dichloroethyl ether have given encouraging results as a soil insecticide against the sugar-beet wireworm and the Pacific coast wireworm as well as the raspberry root borer.

Sprays of phenothiazine were fairly effective against the tomato fruitworm, Mexican bean beetle, and southern armyworm, and slightly useful against the tomato and tobacco worms. This material was also highly toxic to the raspberry fruitworm but caused such serious injury to the raspberry plants as to preclude its further use for the purpose.

In limited experiments metaldehyde proved very effective against slugs and snails in Maryland and California.

SWEETPOTATO WEEVIL CONTROL AND ERADICATION

The program which was begun in July 1937 to eradicate the sweetpotato weevil from areas of commercial production where wild host plants do not persist through the year was continued, and inspection was extended to areas not previously scouted for the pest. Surveys were conducted during the year in 62 counties in Alabama, Georgia, Mississippi, and Texas, 24 of which were found to have infestation in seedbeds, fields, or stored potatoes.

Eradication activities included the destruction of infested seedbeds, clean-up of infested fields and storage places, and the destruction of volunteer sweetpotato plants on infested and adjacent properties. In Alabama native host plants were eradicated from extensive areas along the coast by relief labor under a State-sponsored W. P. A. project.

The regulations of the standardized State quarantine were strictly enforced in cooperation with the States.

COTTON INSECT INVESTIGATIONS

In March 1939 the laboratory for the investigation of the cotton flea hopper at Port Lavaca, Tex., and in June the laboratory for investigation of the cotton bollworm at College Station, Tex., were closed and the work was consolidated with headquarters at Waco, Tex. Both insects are normally serious pests of cotton in the Blacklands section, and large areas of cotton on both river-bottom and prairie land, typical of central Texas, are available for conducting experiments in the vicinity of the new station. In addition, investigations will be undertaken in cooperation with the Soil Conservation Service on their Blacklands Experimental Watershed (Brushy Creek project) to determine the relation of conservation measures to the abundance of cotton insects, and for developing cultural practices for their control.

In June 1939 an employee of the Division was transferred to the lower Rio Grande Valley of Texas to secure information on the life history and habits of the pink bollworm in the new environment for immediate use in the eradication program to be undertaken by the Division of Pink Bollworm and Thurberia Weevil Control.

BOLL WEEVIL

Although the damage caused by the boll weevil in 1938 was almost double that of 1937, it was about 2 percent less than the average

annual damage for the United States during the last 25 years. The severest damage since 1932 occurred along the Atlantic seaboard in Virginia, North Carolina, South Carolina, Georgia, and Florida, but in other sections a hot, dry period during the first half of July temporarily checked a high early-season infestation and permitted the early-planted cotton to mature before the weevils became sufficiently abundant to cause great injury, although late-planted cotton was seriously damaged. Large areas of cotton in the central and western parts of the Cotton Belt were defoliated by the leaf worm during September 1938, and this greatly reduced the numbers of weevils entering hibernation. At Tallulah, La., only 4 live boll weevils per ton of Spanish moss were found in the fall of 1938 as compared with 51 weevils per ton in 1937. This was the smallest number of weevils per ton of Spanish moss in the fall since the examinations were begun in 1925. In the eastern part of the belt defoliation by leaf worms was light, and large numbers of weevils went into hibernation. At Florence, S. C., winter examinations of trash from woods adjacent to cottonfields revealed 3,582 weevils per acre as compared with 1,476 in 1937. Most of the weevils were found in trash within 100 feet of the edge of the woods. The survival in hibernation cages during the winter of 1938–39 was somewhat lower than during 1937–38 and also lower than the average survival for the last 8 years. At Florence the survival was 2.54 percent, at Tallulah 1.16 percent, and at College Station 2.56 percent. At Florence weevils again emerged from hibernation in nature much later than in the cages. Eighty percent of the emergence in the cages occurred during May, whereas only 10 percent of the total number of weevils collected in a trap plot of cotton were taken during May and 33 percent after June 15, when squares were present.

In experiments in boll weevil control in Tallulah, in which over a period of years the standard treatment of calcium arsenate dust had been used after 10 percent of the squares had become infested, the average gains for the year were 188 pounds of seed cotton per acre, or 9.6 percent, as compared with an 18-year average of 322 pounds. Experiments were continued in several localities with mixtures of calcium arsenate and other materials that might control the boll weevil with smaller quantities of arsenic and at the same time control the cotton flea hopper, leaf worms, and other insects. At Florence, where the boll weevils were abundant and flea hoppers very scarce, plots dusted with mixtures of calcium arsenate and lime (1 to 1 and 1 to 2) made an average gain of 352 pounds of seed cotton per acre; those dusted with calcium arsenate and sulfur (1 to 1 and 1 to 2), a gain of 484 pounds; and those treated with calcium arsenate undiluted, 522 pounds. At State College, Miss., where the boll weevil infestation was moderate and cotton flea hoppers and the rapid plant bug scarce, the infestation and yield records showed no significant differences between the insecticides; in late-planted cotton, where the weevil damage was heavy, use of the 1-to-1 mixture of calcium arsenate and sulfur brought about a gain of 666 pounds of seed cotton per acre, as compared with 626 pounds when undiluted calcium arsenate was used. At Tallulah, where the weevil infestation was light and the tarnished plant bug and rapid plant bug more abundant than in Mississippi, the gain from mixtures of calcium arsenate and sulfur (1 to 1 and 1

to 2) applied at the rate of 12 pounds per acre was 212 pounds per acre, or the same as from calcium arsenate, undiluted, applied at the rate of 4 to 6 pounds per acre; on late-planted cotton in which boll weevils were abundant and the rapid and tarnished plant bugs fairly abundant, sulfur dust alone was responsible for an increase of 105 pounds of seed cotton per acre; calcium arsenate-sulfur (1 to 1) for 488 pounds, and calcium arsenate, undiluted, for 438 pounds.

At College Station, Tex., with a light boll weevil and light flea hopper infestation, the use of calcium arsenate-sulfur mixtures (1 to 1 and 1 to 2) resulted in gains of 337 pounds of seed cotton per acre, and the use of calcium arsenate, undiluted, in 379 pounds.

Cage tests for the control of the boll weevil in which calcium arsenates containing low, intermediate, and high percentages of water-soluble arsenic pentoxide as determined by the New York method were continued, the average net mortalities for the 2 years being 60 percent with the low (0.4 percent), 78 percent with the intermediate (4.5 percent), and 76 percent with the high (10.5 percent). A cooperative field test of these high, intermediate, and low calcium arsenates was made at six stations of the Division and at the Texas Agricultural Experiment Station. In all, 8 tests, consisting of a total of 45 replications for each treatment, representing different climatic and boll weevil conditions, were made. Randomized-block plot arrangements were used, the plots being one-thirtieth of an acre in area. Statistically, the square infestations and yields did not differ in the plots receiving calcium arsenates containing low, intermediate, and high percentages of water-soluble arsenic pentoxide. However, both high and intermediate calcium arsenates appeared to be slightly more toxic to the weevils in cage tests, whereas in field tests the yields in plots dusted with the low were slightly better. Since the results obtained in the field plots are not in accord with those of the cage tests, the tests are being repeated this year in an attempt to find which type of calcium arsenate is best under field conditions.

The addition of several wetting agents to calcium arsenate and cryolite dusts did not significantly affect the insect mortality in cage tests. Dicalcium arsenate caused a significantly higher boll weevil mortality in cage tests than did tricalcium arsenate and commercial calcium arsenate.

In field tests with cryolite conducted at Florence, Tallulah, and College Station much better control was secured than last year, and material containing a high percentage of sodium fluoaluminate was more effective than that used previously. The physical qualities of the cryolites are very poor for dusting.

Continued experiments on boll weevil control on sea-island cotton at Tifton, Ga., and Gainesville, Fla., where the infestations were heavy in 1938, again demonstrated that adequate protection against the late-season migratory weevils constitutes the crucial problem in control on long-staple cotton. At Gainesville the best control was secured by using a spray of calcium arsenate (10 pounds to 50 gallons of water) applied with small compressed-air sprayers at the rate of 20 to 30 gallons per acre. The yield was increased 127 percent. The second-best gain was obtained with calcium arsenate dust—119 percent over the checks. At Tifton spraying with 5 pounds of calcium arsenate to 1 gallon of cane syrup and 49 gallons of water gave good

control prior to migration but did not protect the bolls from attack. At both localities undiluted calcium arsenate dust gave better control than the diluted dusts, and mopping with sweetened poison was again entirely inadequate for protection against the weevils.

SOIL INJURY FROM CALCIUM ARSENATE AND CRYOLITE

The 1938 yield of cotton on the plot at Tallulah which received 400 pounds of calcium arsenate per acre from 1931 to 1935, or a total of 2,000 pounds, was less than that on the untreated check, probably owing to the reduced growth in 1937 of Austrian Winter peas and hairy vetch planted for green-manure crops. During the winter of 1938–39 Austrian Winter peas, vetch, and oats planted as winter cover crops produced as much on the treated as on the untreated plots for the first time since the experiment was begun. It appears that the injurious effects of arsenic on the soil disappeared after 4 years. On the plots representative of the seven major soil types of Mississippi, previously reported, the effects of arsenic added in April 1935 seem to be disappearing as a result of fixation or leaching of the arsenic, and the yields from crops susceptible to arsenical injury are increasing. Preliminary tests with cryolite on light sandy soils especially susceptible to arsenical injury indicate that applications up to 2,000 pounds per acre had no deleterious effect on the germination or growth of cowpeas and oats.

COTTON FLEA HOPPER

There was a very heavy infestation of the cotton flea hopper in southern Texas, and the gains from dusting experiments in 1938 were the highest ever obtained. The average gain from dusting with several insecticides on thirty-six 1-acre plots was 311 pounds of seed cotton (53 percent) over the checks, and the net profit was $9.74 per acre. The maximum gain of 680 pounds and a profit of $25.11 per acre followed dusting with a mixture of 1 part of calcium arsenate and 2 parts of sulfur, and showed that this mixture is superior to other proportions of calcium arsenate and sulfur and to sulfur alone. This mixture is now being used extensively by growers, the applications being made from airplanes and ground dusting machines. Very finely divided or "micronized" sulfur dusted at the rate of 7 pounds per acre was as effective as 15 pounds of ordinary 325-mesh dusting sulfur. Mixtures of sulfur and barium fluosilicate or cryolite were not effective against the flea hopper.

HEMIPTEROUS INSECTS

The hemipterous insects continue to be the most important insect enemies of cotton in Arizona. Among the more important species are the pentatomids *Euschistus impictiventris* Stål, *Chlorochroa sayi* Stål, and *Thyanta custator* (F.) and the mirids *Lygus hesperus* Knight, *L. pratensis oblineatus* (Say), *L. elisus* Van D., and *Creontiades femoralis* Van D. The last species was more abundant on cotton in 1938 than in previous years. The pentatomids feed on the larger bolls, causing malformation and staining of the lint by the introduction of pathogenic organisms. A survey of the cotton in the State showed that 31.5 percent of the bolls of short-staple and 14.6 percent of those of long-staple cotton had been punctured. The mirids injure

the terminal buds of the plants and also cause shedding of large numbers of squares and small bolls. Further studies on seasonal abundance and host-plant relationships confirmed previous observations that alfalfa, sugar beets grown for seed, grain sorghum, and desert vegetation are the principal sources of the populations that move to cotton during the latter part of June and in July. Accurate determination of the populations, as a basis for beginning control measures, is difficult, and no satisfactory method has been developed.

Major attention was given in 1938 to field tests on the relative efficiency of the insecticide which had previously given the best results, the number of applications, and intervals between dusting for the most economical gains. Tests were conducted with sulfur dust and with dust mixtures of paris green and sulfur (1 to 12) and calcium arsenate and sulfur (1 to 4) in three sections of the State. The gains from the control experiments, while not so large as in 1937, resulted in profitable increases in yields and better grades of cotton when 5 to 9 applications of 15 to 18 pounds of insecticides were applied at 7-day intervals. Applications at 7-day intervals gave better results than those at 14-day intervals.

At Mesa, where the infestation was very light, the gains were as follows: From the paris green-sulfur mixture, 375 pounds of seed cotton per acre, or an increase of 14.4 percent; from calcium arsenate and sulfur, 168 pounds, or 6.5 percent; from sulfur, 157 pounds, or 6 percent.

At Buckeye, where the infestation was moderate, the gains were as follows: From sulfur, 1,620 pounds, or 102 percent; from calcium arsenate and sulfur, 791 pounds, or 41 percent; from paris green and sulfur, 392 pounds, or 31 percent.

In the Yuma Valley, where the infestation was heavy, the final yields from the experiments were unfortunately not obtained. However, in the first picking the best gain was from the calcium arsenate-sulfur mixture, where the increase was 549 pounds of seed cotton per acre, or 28 percent over the checks.

An entire farm of 3,133 acres of cotton near Tucson was dusted by airplane under the general supervision of the Bureau, and while no checks were left, the management was so well pleased with the results that the entire acreage will be dusted again in 1939 if necessary.

BOLLWORM

The bollworm infestation at College Station, Tex., was again late, and the control experiments were limited to the second brood of worms, which appeared on late-planted cotton during August. No rain occurred from July 8 to October 17, and cotton began wilting and shedding squares; consequently a heavy bollworm infestation did not develop. The insecticides tested in 1938 were calcium arsenate, barium fluosilicate, and synthetic cryolites containing from 20 to 90 percent of sodium fluoaluminate. Three applications of each were made at 5- to 7-day intervals beginning on August 7, when an average of 28 bollworm eggs per 100 terminal buds were present. The control from the calcium arsenate and barium fluosilicate was equal, resulting in an increase of 366 and 371 pounds of seed cotton per acre, or 41 percent. The gains from the cryolite containing 20 percent and 85 percent of sodium fluoaluminate were likewise approxi-

mately equal, the increases being 204 and 210 pounds, or 23 percent. The cryolite containing 90 percent of sodium fluoaluminate increased the yield 12.5 percent, and a cryolite with coarse particles containing 78 percent of sodium fluoaluminate, only 9.5 percent. In comparisons of calcium arsenates containing high (10.5 percent), medium (4.5 percent), and low (0.4 percent) water-soluble arsenic as determined by the New York method the increases in yields over the checks were 402, 309, and 531 pounds of seed cotton, respectively.

In tests at College Station extending over 10 years calcium arsenate dust applied at the rate of 8 to 10 pounds per acre, beginning when from 25 to 35 eggs per 100 terminal buds are present and repeated at 5-day intervals as long as oviposition continues, has proved the most effective and economical for control of the bollworm. The effectiveness of the insecticide depends on the distribution and timeliness of the application.

PINK BOLLWORM

The infestation of the pink bollworm in the Big Bend area of Texas in 1938 was much heavier than in previous years. A very early fall clean-up of the crop debris, together with overflows from the Rio Grande in July and September, which left the soil unusually moist, materially reduced the number of worms entering hibernation and the winter survival and resulted in a low carry-over to the spring of 1939. Experiments to determine the percentage of worms going into hibernation at different dates showed that 0.33 percent of the larvae issuing from green bolls between September 1 and 15, 7 percent of those issuing between September 16 and 30, and 20 percent of those issuing between October 1 and 15 were of the long cycle. The experiments were interrupted by the floods but clearly indicate the value of the early fall destruction of cotton stalks, since it is known that practically all the larvae maturing later in the season go into hibernation. Larvae in bolls plowed under 6 inches deep early in December, in fields afterwards given two winter irrigations, again had the lowest survival. The time and rate of moth emergence in the spring were influenced by the temperature and the amount of moisture in the soil. When the larvae were kept over winter under optimum moisture conditions or the moisture was increased in the spring by an irrigation, they pupated earlier and moth emergence was completed sooner than when soil moisture was low. There was a higher survival in heavy adobe soils than in light sandy soils, and in cocoons left on the soil surface than in those buried 2 to 6 inches deep. Bolls of *Thurberia thespesioides* were readily attacked by the pink bollworm when grown in close proximity to infested cotton, and moths emerged from larvae overwintering in bolls kept in hibernation cages.

In the work with parasites, the stocks of the Hawaiian strain of *Microbracon mellitor* (Say) were liberated and breeding of this species was discontinued for the present. A total of 93,000 *M. nigrorufum* Cush. and 497,000 *Chelonus blackburni* Cam. were liberated during the year in the Presidio Valley of Texas and the Laguna and Las Delicias districts of Mexico. The liberations were made in Texas early in the season, but the shortening of the breeding period by floods and early clean-up made conditions very unfavorable. Both species were recovered near the points of liberation, but definite establishment has not been determined.

Insecticide tests in which arsenicals, fluorine compounds, fixed nicotine, and phenothiazine dusts were used were continued on small plots arranged in Latin squares. On the basis of the reduction in the numbers of worms per boll the fluorine compounds and fixed nicotine gave more promising results than any of the other insecticides that have been tested at Presidio.

ROOT APHIDS

Of the three species of root aphids injurious to cotton, *Trifidaphis phascoli* (Pass.) causes the most severe damage. There appears to be a correlation between the presence of the aphids and the incidence of seedling diseases. In control experiments directed against the aphids and the attending ant (*Lasius niger neoniger* Emery), the following have been used: (1) Repellents applied to the seedbed before planting and around the plants, (2) fumigants applied before and after planting, and (3) poisoned baits for the ants. The repellents and fumigants tested included oil of tansy, oil of sassafras, oil of anise, oil of lemon, kerosene, tincture of asafetida, flake naphthalene, derris, sulfur, tobacco dust, paradichlorobenzene, ethylene dichloride, and dichlorethyl ether emulsified with fish-oil soap in water. On the plots treated with paradichlorobenzene, the germination was very poor and the plants were stunted. The oil of tansy treatment delayed germination about 24 hours, whereas the derris hastened germination by 24 hours. No effect on the germination was noted as a result of the other treatments. The paradichlorobenzene was also the only treatment that controlled the aphids.

The ant poisons used were varying amounts of thallium sulfate, thallium acetate, and tartar emetic in sweetened baits made with sugar and honey or honey and water. The poisons, absorbed on strips of blotting paper, were exposed on the soil or in perforated tins and on sponges in tins. Tartar emetic (2 ounces mixed with 1 gallon of water, 1 pound of sugar, and 2 ounces of honey) was more effective than the thallium poisons, although more species of other ants were attracted to the thallium baits because of the higher concentration of sweets used. Counts of the number of active anthills were found not to be a good criterion of the aphid control, and no definite conclusions were drawn. Cotton following corn interplanted with cowpeas or soybeans that serve as late-season hosts for the aphids was much more seriously damaged by aphids than cotton following cotton, tobacco, or small grain.

COTTON LEAF WORM

In 1938 the first report of the cotton leaf worm in the United States came from Port Lavaca, Calhoun County, Tex., on May 2. This was more than a month earlier than the first report in 1937, and was the earliest record in recent years. Leaf worms were reported in various parts of southern and eastern Texas during May and June. The first leaf worm reported from the vicinity of College Station, Tex., was collected on June 18. The worms were found in Madison Parish, La., on July 6. On July 7 full-grown worms were found in Presidio County in the Big Bend section of Texas—a very early date for that section. On July 16 the worms were reported from Garvin County, Okla., Columbia County, Ark., and Holmes County, Miss., and on July 28 from Pima County, Ariz. During August they were

reported from Alabama, Tennessee, and South Carolina, and during September from Georgia, Florida, and Missouri. Although leaf worms reached cottonfields of all cotton-growing States except California in 1938, the infestations were generally rather spotted until late in the season. In the Southeastern States the worms appeared late, the infestations were light, and few growers used control measures. However, in the Delta section of Mississippi and in the States west of the Mississippi River many growers applied arsenical poisons to control the leaf worm. During 1938 the leaf worm moths apparently entered this country from the south only through Texas, the evidence indicating that they did not enter also through Florida as in some years. All the arsenical insecticides used for spraying or dusting plants appear to be effective against the leaf worm. Experiments at Tallulah indicate the value of arsenicals high in water-soluble arsenic pentoxide for use against the leaf worm. There was a direct correlation between the amount of water-soluble arsenic pentoxide in calcium arsenates and their effectiveness in causing mortality of leaf worms. Those highest in water-soluble arsenic pentoxide produced mortality with the smallest doses, and those lowest in water-soluble arsenic pentoxide required the largest doses. The cryolites tested were less effective against the leaf worms than were the calcium arsenates.

VARIETAL RESISTANCE OF COTTON TO INSECTS

Work is being continued at Stoneville, Miss., to secure basic information for use by plant breeders in developing varieties of cotton that may be tolerant or immune to the boll weevil, aphids, and thrips. More than 2,000 species, varieties, and strains of cotton are available for study. From the 44 varieties previously studied, 12 commonly grown varieties were selected, the seeds of which had been self-fertilized for 4 years. Bolls 20 days old collected from each of these varieties which were intermediate in thickness and showed the maximum toughness of carpel lining are being further tested to determine whether this type of boll continues to show the greatest resistance to the boll weevil. From each of these varieties selections have been made of the plants which were determinate in growth, had heavy leaf drop, and maintained light aphid populations. Under natural conditions the plants with the lightest aphid populations have been the poorest in producing fruit. The positive correlation between pilosity of the plants and aphid populations on undusted cotton has been further confirmed. Dusting with calcium arsenate increased the aphid population on all types of cotton. Thrips were most abundant on the pilose cottons, which have large cluster-type buds in which the insects are sheltered.

PINK BOLLWORM CONTROL

The most outstanding developments in the pink bollworm situation for the 1938 crop season were the discovery of a light pink bollworm infestation in the Coastal Bend section of Texas, the finding of reinfestation in the Salt River Valley of Arizona following several years of freedom from infestation, and the disclosure of a heavier infestation in the lower Rio Grande Valley of Texas and Mexico.

INFESTATION IN THE COASTAL BEND AREA

The Coastal Bend quarantine district of Texas includes the counties of Brooks, Kleberg, Jim Wells, Nueces, and the northern half of Kenedy. The first pink bollworm infestation was found in gin trash at Kingsville, in Kleberg County, on July 27, 1938. A proclamation was issued by the Governor declaring these counties a pink bollworm regulated area, and on August 8 an amendment to the State pink boll worm quarantine proclamation was issued by the commissioner of agriculture, establishing rules and regulations governing the movement of cotton and cotton products for the remainder of the season. There was no seed sterilization at gins during the 1938 season because no facilities were available at the time for sterilization of cottonseed; however, gins were required to observe all sanitary measures to prevent the contamination of lint. Seed sterilization was required for outside movement only.

Effective November 17, 1938, Federal Pink Bollworm Quarantine No. 52 was revised to include the counties of Brooks, Jim Wells, Kenedy, Kleberg, and Nueces as part of the lightly infested regulated area. At the end of June practically all ginners in the Coastal Bend district had made definite arrangements for the installation of sterilizers as a continuous process of ginning, and a considerable number of these machines had been installed.

A proclamation was issued by the State of Texas on September 21, 1938, making the destruction of 1938 stalks mandatory and establishing the dead line for completion of such work by October 15. This date was later extended to November 1, however, owing to climatic conditions. At the expiration of this date stalks had been cut in all fields with the exception of 456 acres, most of which was destroyed by December 1. Also, most of the volunteer or stub cotton was destroyed by the end of December. Of the estimated 215,343 acres of 1938 cotton, only 12,054 acres remained unplowed on November 1. In connection with the stalk-destruction program, the State Department of Agriculture found it necessary to file two complaints for noncompliance. Stalks in both these fields were destroyed shortly thereafter.

CONTROL IN THE LOWER RIO GRANDE VALLEY

The fight against the pink bollworm in the lower Rio Grande Valley of Texas and Mexico is considered by the two countries as a common problem. Approximately 260,000 acres were planted to cotton in the four counties involved on the American side and 150,000 in the Mexican regulated area in this valley for the 1938 crop season.

Gin-trash inspections of the 1938 cotton crop in the lower valley area revealed a considerable increase in the degree of infestation over that of the 1937 crop. Consequently, a more vigorous clean-up was planned and carried out during the 1938 crop season. The State of Texas issued an amendment to the stalk-destruction proclamation for that area requiring that all stalks be cut by October 1 and that the plowing up of roots to prevent stub growth be completed by October 15.

On May 1, 1939, one specimen of the pink bollworm was found on a stalk of sprout cotton in a field about 8 miles northwest of Browns-

ville, in Cameron County. Bloom inspection was immediately begun in the 1939 cotton crop, and by June 30, 12 infested fields had been located in Cameron County, and 1,885 specimens of the pink bollworm had been found through bloom and boll inspection, 1,836 of these specimens coming from 2 heavily infested fields. These findings indicated that a much heavier infestation was present in Cameron County in the 1939 crop than existed during the previous season. Considerable inspection of this type gave negative results for the other three regulated counties as of June 30. In the Matamoros district 16 specimens of the pink bollworm were found through bloom inspection during May, but unfavorable weather prevented a sufficient amount of inspection to indicate the degree of infestation in that district.

CONTROL PROGRAM IN THE BIG BEND AREA

Owing to the extremely heavy pink bollworm infestation in the 1937 cotton crop in the Big Bend area of Texas and Mexico, Department of Agriculture authorities of the United States and of Mexico, in cooperation with the State Department of Agriculture, evolved a program, referred to as the "2-year plan," with the objective of materially reducing the pink bollworm infestation in the Presidio-Ojinaga area by the early planting and harvesting of the 1938 cotton crop, followed immediately by the clean-up of fields; delayed planting of the 1939 cotton crop; and the elimination of all stub or volunteer cotton in the spring of 1939 so that no fruit would be available to emerging pink bollworm moths before the maturity of the main cotton crop.

A Texas State proclamation was issued in January 1939 prohibiting the planting of cotton in the affected area until April 20, and a similar proclamation was issued by the Mexican Department of Agriculture for the Ojinaga district. This uniform planting date was observed very closely on both sides of the Rio Grande, as was also the destruction of all stub cotton. It is believed that the spring emergence of pink bollworm moths in that area was practically over by June 10, and no fruit sufficient to maintain and propagate the pink bollworm was found present on cotton plantings before June 17, thus creating a host-free period of several months' duration. Inspection of material from the 1939 crop is awaited with interest.

REINFESTATION IN ARIZONA

In the fall of 1938 an infestation of the pink bollworm was found in the eastern end of the Salt River Valley of Arizona in Maricopa County, in practically the same location where the first pink bollworm infestation was discovered in 1929. Also, a light infestation was again found in the Coolidge district of Pinal County early in November.

As a result of these findings, Federal Quarantine No. 52 was revised effective November 17, 1938, to add to the lightly infested areas in Arizona all of Maricopa County and that part of Pinal County not heretofore within the regulated area. With the additional area involved by these new findings a light general infestation of the pink bollworm extended from Tubac, in Santa Cruz County, northward

to Gilbert, in Maricopa County. Following the discovery of pink bollworm infestation in the 1938 crop, immediately after cotton was picked, early in December, field clean-up operations were begun in the center of the heaviest known infestation, involving 3,100 acres. The Arizona Legislature supplemented the Department fund of $15,000 available for this work with a like amount. The program consisted of cutting, raking, and burning the cotton stalks as soon as the cotton was picked and the plowing of fields to prevent sprouting from the roots and the producing of fruit to propagate and maintain the pink bollworm prior to the fruiting of the 1939 cotton crop. This phase of the program was completed in mid-March.

The completion of these control measures was followed by a spring program, inaugurated on April 10, the objectives of which were as follows: (1) To prevent the growth of all stub cotton, (2) to secure the plowing up of all abandoned cotton fields by April 20, (3) to delay the planting of upland cotton until April 10 and prevent the fruiting of any cotton until June 20. It soon became apparent that some volunteer cotton could not be eliminated from the areas affected, and as the State of Arizona did not have authority to forbid the growing of stub cotton, the assistance of the Agricultural Adjustment Administration was sought. As a result, the A. A. A. issued a regulation on April 29 requiring the destruction of all stub cotton in the area, and this resulted in destruction of 5,210 acres of abandoned volunteer cotton and 288 acres of cultivated stub, nearly all in Pinal County.

Planted cotton was held back by volunteer cooperation among the growers, either by delayed planting, by withholding water, or both. Indications are that prior to June 20 there was no cotton in fruit sufficient to propagate the pink bollworm in Pinal County or in that part of Maricopa County where eradication work was carried on, except in a few isolated plantings.

SITUATION IN OLDER REGULATED AREAS

Gin-trash inspection in the El Paso Valley district during the 1938 season indicated that there was no material change in the status of pink bollworm infestation over the previous season in that district except in lower Hudspeth County, where it was somewhat heavier. Inspections made in the Juarez Valley of Mexico, across the Rio Grande from this district, and also in Vado and Villa Ahumada, Mexico, indicated that infestation in those localities was rather heavy. The Texas Panhandle district was given the most thorough inspection during the 1938 crop season it has had for a number of years. As a result, it was found that the infestation, while very light, was rather well distributed. The greatest number of worms were found in Midland County, where 16 were taken from 482 bushels of trash. One specimen was found in Lamb County, which is the first finding since the county was originally found infested in the 1933 crop. In the Pecos Valley district inspections in Ward, Reeves, and Pecos Counties disclosed a general infestation averaging about 17 worms per bushel. In the Presidio area infestation was somewhat heavier than during the previous year.

A summary of the amount and results of the various types of inspection is given in table 11.

TABLE 11.—*Summary of inspections for the pink bollworm in regulated areas, crop season of 1938*

State and county	District	Gin trash		Field		Laboratory	
		Quantity	Pink bollworms	Man-days	Pink bollworms	Green boll samples	Pink bollworms
Arizona:		*Bushels*	*Number*	*Number*	*Number*	*Number*	*Number*
Graham	Arizona	676	142	0	0	0	0
Maricopa [1]	do	22,485	116	31	6	0	0
Pima [2]	do	2,222	7	0	0	0	0
Pinal [1]	do	5,599	4	0	0	0	0
Santa Cruz [2]	do	54	2	0	0	0	0
Total		31,036	271	31	6	0	0
New Mexico:							
Chaves	El Paso Valley	244	3	0	0	48	0
Dona Ana	do	66	44	0	0	91	1
Eddy	do	145	396	0	0	52	12
Lea	Panhandle	0	0	0	0	32	2
Luna	El Paso Valley	9	137	0	0	24	93
Roosevelt	Panhandle	167	0	0	0	0	0
Total		631	580	0	0	247	108
Texas:							
Brooks [3]	Coastal Bend	68	2	0	0	101	0
Jim Wells [3]	do	1,203	1	0	0	0	0
Kleberg [3]	do	448	5	0	0	0	0
Nueces [3]	do	5,403	5	0	0	0	0
Cameron	Lower Rio Grande Valley	415	324	0	0	0	0
Hidalgo	do	1,103	6	0	0	0	0
Starr	do	230	0	0	0	0	0
Willacy	do	1,161	5	0	0	0	0
Andrews	Panhandle	178	6	0	0	13	0
Bailey	do	669	0	0	0	24	0
Cochran	do	495	2	0	0	0	0
Dawson	do	3,030	4	0	0	0	0
Gaines	do	661	1	0	0	28	0
Hockley	do	2,876	0	0	0	13	0
Howard	do	1,855	2	0	0	28	0
Lamb	do	5,134	1	0	0	0	0
Martin	do	1,198	0	0	0	0	0
Midland	do	482	16	0	0	8	0
Terry	do	2,554	1	0	0	29	0
Pecos	Pecos Valley	66	119	0	0	29	0
Reeves	do	102	2,747	0	0	28	3
Ward	do	103	1,924	0	0	42	6
El Paso	El Paso Valley	31	116	0	0	106	22
Hudspeth	do	43	11,873	0	0	40	0
Total		29,508	17,160	0	0	489	31
Grand total		61,175	18,011	31	6	736	139

[1] Inspections made before Maricopa County and part of Pinal County were brought under regulation.
[2] A total of 603 Thurberia weevils were taken from gin trash examined from Pima and Santa Cruz Counties.
[3] These counties were brought under regulation after inspections were made.

INSPECTION OUTSIDE REGULATED AREAS

Owing to the fact that heavier pink bollworm infestations were found in the 1938 cotton crop in the lower Rio Grande Valley and adjacent Matamoros, Mexico, it was deemed necessary to make a thorough inspection of counties throughout southern Texas. As a result infestation was found in Kleberg, Brooks, Nueces, and Jim Wells Counties, lying in close proximity to the lower Rio Grande Valley, and these counties were later added to the area regulated on account of the pink bollworm. Gin-trash inspection was also carried on in Texas

counties adjacent to the regulated area of the Panhandle district, but no new territory was involved. Intensive gin-trash inspections were made in the southeastern, central, and southwestern parts of Oklahoma, in almost all the cotton-producing counties of Louisiana west of the Mississippi River, and in the Delta counties of Mississippi. Inspections were begun in northern Florida and progressed northward to the central parts of Georgia and Alabama. Results of inspection in all States were negative as to pink bollworm infestation with the exception of Texas. Inspections in the Matamoros section of Mexico, opposite the lower Rio Grande Valley of Texas, revealed a heavy increase in pink bollworm infestation, 15,364 worms being taken from 499 bushels of gin trash, whereas in the 1937 crop the average was slightly less than 2 worms per bushel. At Reynosa, Mexico, 9 pink bollworms were found in 322 bushels of gin trash as against none in the 1937 crop.

A summary of the amount and results of the various kinds of inspection is given in table 12.

TABLE 12.—*Summary of inspections for the pink bollworm outside regulated areas, crop season of 1938*

State	Gin trash		Field		Laboratory	
	Quantity	Pink bollworms	Man-days	Pink bollworms	Samples	Pink bollworms
	Bushels	*Number*	*Number*	*Number*	*Number*	*Number*
Alabama	4,576	0	0	0	0	0
Arizona	315	0	0	0	0	0
California	26	0	0	0	0	0
Florida	1,094	0	66	0	825	0
Georgia	6,179	0	45	0	582	0
Louisiana	4,848	0	0	0	0	0
Mississippi	639	0	0	0	0	0
New Mexico	0	0	0	0	100	0
Oklahoma	7,641	0	0	0	141	0
Texas	54,121	0	6	0	1,510	0
Total	79,439	0	117	0	3,158	0
Mexico:						
Baji California	1,417	0	0	0	0	0
Nuevo Leon	113	0	0	0	0	0
Tamaulipas	938	15,373	0	0	0	0
Total	2,468	15,373	0	0	0	0
Grand total	81,907	15,373	117	0	3,158	0

WILD COTTON ERADICATION

Especially good progress was made in the eradication of wild cotton in southern Florida, the first cleaning being completed in all areas in time to prevent any unusual amount of cotton from maturing seed. There was a decrease of 11,000 wild cotton plants from the number found last season in the Fort Myers district and a decrease of 67,000 in the Keys district. However, there was a small increase of wild cotton plants as a whole in the Ten Thousand Islands section, but a very decided decrease in the number of fruiting plants. The greatest increase was in the Cape Sable section—this being the largest continuous wild cotton area—where 362,000 wild cotton plants were destroyed, or about a 50-percent increase over last season. These facts are very

interesting, in that few or no mature seed have fallen to the ground during the past several years, and all seed that germinated this season must have been from 2 to 7 years old.

During the 1938 season 34,205 acres were covered in southern Florida in the removal of wild cotton plants. Practically all this acreage was gone over twice, and a great portion of it was covered three times. A total of 46,103 plants with mature bolls were found and destroyed and 1,409,438 seedling plants removed. Only 2,043 sprout plants were found during the season.

THURBERIA WEEVIL CONTROL

The area in Arizona now regulated on account of the Thurberia weevil includes Cochise and Santa Cruz Counties and parts of Graham, Pinal, and Pima Counties, this area also being regulated by the pink bollworm quarantine. During the greater part of this year eradication work was carried on in the Santa Catalina Mountains from camps established at various points throughout that mountain range. During the last few months, however, *Thurberia* eradication was carried on in the vicinity of Sahuarita and the Continental ranch in the Santa Cruz Valley and in the large canyons west of the Tucson-Nogales Highway, and laborers have been transported back and forth from Tucson to work. During the fiscal year ended June 30, 1938, 98,020 acres were covered and 444,720 *Thurberia* plants destroyed, bringing the total acreage covered since this work started to 298,170 and the number of plants destroyed to 1,764,762. Funds to carry on this work are provided by Work Projects Administration allotments, together with funds allocated by this Bureau.

BEE CULTURE

In the Bureau's cooperative program on American foulbrood, participated in by the Arkansas, Iowa, Texas, Wisconsin, and Wyoming Agricultural Experiment Stations, over 700 queens of resistant stock were reared by the Texas station during the spring of 1939 for distribution to cooperating beekeepers.

In 1938, when strains of bees were being tested for resistance to American foulbrood at the Bureau's Wyoming laboratory, 27 out of 40 inoculated colonies which contained queens of the F_2 and F_3 generations either recovered or failed to contract the disease, whereas out of 27 colonies headed by 14 queens from stock with an unknown history for disease resistance and 13 from F_1 queens of stock showing resistance only 12 recovered or failed to contract the disease. The data show that an increase in resistance was obtained over that in 1937. Work by the Iowa Agricultural Experiment Station the same year with 111 line-bred queens reared by the Texas station also indicated a gain in resistance. This increase apparently was the result of selective line breeding, although some undesirable characteristics, such as nervousness and a tendency toward irregular-spotted brood nests, seem also to have been intensified.

The Iowa station in 1938 distributed to commercial beekeepers 888 Texas-reared queens of resistant stock. The Bureau's Wyoming station distributed 667 similar queens in Colorado, Minnesota, and Wyoming. Cooperators reported less disease in this stock than in stock obtained from other sources.

Three colonies out of 26 given opportunity in an isolated locality to rob honey contaminated with American foulbrood failed to contract the disease, although the others became infected, in tests on the relation of robbing to spread of the disease carried on by the Wyoming Agricultural Experiment Station. The queens from the three colonies were sent to Texas for breeding purposes.

A new sublaboratory was established on February 1 at Hope, Ark., in cooperation with the Arkansas Agricultural Experiment Station. The long season in southern Arkansas will be used to advantage in supplementing the work on disease resistance. In addition, the program for the laboratory includes maintaining a reservoir of resistant strains and rearing queen bees for testing elsewhere by the Bureau and its cooperating agencies.

That house-cleaning activities of the worker bees play an important part in disease resistance is demonstrated by the large amount of healthy brood reared in cells from which the bees have cleaned out diseased remains. Where reinfection occurs in such cases, infected food rather than remaining diseased material appears to be the cause. The fact that brood from resistant queens showed no less disease than that from nonresistant queens when placed in heavily diseased colonies further points to the importance of the house-cleaning behavior of bees.

The time required for the removal of diseased brood ranges from 1.2 to 10.9 days. The degree of resistance, however, is not entirely correlated with the rapidity of cleaning out the disease. Cells found diseased on one inspection are not likely to be found later if inspections are spaced several days apart. Light infections are thus apt to be overlooked if inspections are made infrequently.

The effect of 8-hydroxyquinoline sulfate at a dilution of 1 to 1,000, added to diluted honey containing spores of *Bacillus larvae* and heated, indicates that small amounts of this substance, insufficient to be toxic to adult bees, greatly diminish the amount of heating necessary to kill the spores. The possibility of the use of this chemical to make such honey safe to feed to bees is thus indicated if it can be obtained cheaply enough.

Inoculations of colonies with spores of *Bacillus larvae* heated in diluted honey for periods of 30 minutes to 5 hours did not produce American foulbrood within 2 years, although spores from the same heated batches grew in culture after 3 to 30 days, showing that while the heated spores did not cause disease in a colony neither were they killed.

A positive nitrite-nitrogen test on a medium containing carrot extract but without added nitrite has long been considered specific for *Bacillus larvae*. Two other spore-bearing bacteria have been found, however, and isolated in pure culture but not identified, which give a nitrite-nitrogen test indistinguishable from that of *B. larvae*.

The relationship of particle size to the toxicity of insecticides to honeybees has been tested for lead arsenate, calcium arsenate, phenothiazine, and cryolite. The median lethal dose for fine cryolite (midsize, 2 microns) was found to be 7.5 micrograms per bee; and for medium cryolite (midsize, 28 microns), 23.2 micrograms. The influence of particle size was of about the same order of magnitude for phenothiazine as for cryolite; for lead arsenate it was much greater,

and for calcium arsenate it was much less. Of the four insecticides, phenothiazine is by far the least toxic.

Tests of 14 lines of commercial stock in package colonies showed that loss of queens, poor quality or spotted brood, and low honey production were characteristic of certain lines of stock having a common hereditary background. Only 49.3 percent of the queens survived the producing season, and only 27.9 percent of the original number survived as good queens. The average honey yield for the 14 sources of stock ranged from 21 to 162 pounds, while for individual colonies headed by queens that survived the producing season it ranged from 30 to 310 pounds, as compared with the 60 pounds required for winter.

A survey conducted in Wisconsin in 1937 which included the bees of 17 beekeepers possessing a total of 3,438 colonies showed that many of the keepers were losing honey through weak colonies. The average honey crop per colony for the total number in the survey was 125 pounds, while for the colonies of the individual beekeepers the average ranged from 80 to 300 pounds. The range per colony, when only the highest producing colony of each beekeeper is considered, was from 175 to 600 pounds, the average of these colonies being 378 pounds. Since the average crop of the beekeepers as a whole only equaled one-third the average of these maximum-producing colonies, a failure to harvest the major part of the potential honey crop is indicated.

Enough instances of multiple matings of queens were observed at Beltsville, Md., and Baton Rouge, La., to indicate that such occurrences are not so rare as has been commonly supposed.

The followng chemical analysis (percent) of royal jelly was obtained: Water, 66.05; dry matter, 33.95; protein, 12.34; lipid content, 5.46; reducing substance, 12.49; ash, 0.82; undetermined material, 2.84. No demonstrable amounts of vitamin C were found. The absence of vitamins A and E and the presence of vitamin B have previously been reported.

In cooperation with Louisiana State University royal-jelly extracts fed to rats failed to produce any gonadotropic effect, contrary to what has been suggested by other investigators.

In studying the differentiation between workers and queens, chemical analysis shows the queen to have a higher nitrogen, lipid, reducing-substance, and energy content during the developmental period following the time of differentiation than the worker. During the unsealed larval stage the respiratory quotient of both queen and worker is greater than unity, indicating the synthesis of fat from carbohydrates. During the pupal stage the respiratory quotient of the queen ranges from 0.96 to 0.83, whereas that of the worker is between 1.05 and 0.94. Values of less than unity for the respiratory quotient indicate the conversion of fat and protein into carbohydrates or the incomplete oxidation of metabolites.

The optimum temperature for caged bees was found to be 93.9° F. Other optimum conditions for keeping bees in cages, previously found, are a 50-percent sucrose solution, water ad libitum, and a relative humidity of 20 to 25 percent.

Investigations of the causes of mortality during brood development indicate that the nurse bees may be at fault as well as the queen. Thus when eggs from a queen with uniform brood and those of a

queen with spotted brood were interchanged, the eggs from the first queen showed an increase in brood mortality when reared in the other colony, and vice versa.

The need of winter pollen reserves for maintaining spring brood rearing was brought out in studies at Laramie, Wyo., which showed that pollen consumption occurred throughout the winter in colonies with both abundant and negligible pollen reserves but was considerably greater during winter and increased during March and April in colonies with abundant pollen. In colonies with negligible reserves pollen consumption was less in March and April. Abundant pollen reserves are essential if colony population and vitality are to be at a maximum at the beginning of the active season.

Tests on methods of giving colonies additional pollen showed that mixing it in honey or sirup is of little use, since the proventriculus of the bee acts to separate the pollen before the bees can give it to the brood. The tests showed that no brood was reared beyond the larval stage when pollen was given this way exclusively although egg laying was stimulated.

In a study on pollen substitutes, pollenless colonies responded to being given soybean flour by rearing brood for 10 to 14 days, after which they no longer seemed able to mature their brood. Colonies with negligible amounts of pollen responded to the flour by rearing brood normally for at least 4 to 5 weeks. Colonies receiving soybean flour supplemented by either 25 or 50 percent of pollen gave a brood-rearing response equal to that of colonies fed pollen exclusively.

Pollen traps maintained in four California beekeeping areas yielded from 33 to 40 pounds per colony during the year. The daily production varied with the season, forming curves similar to the brood-rearing curves for the areas. As much as one-half pound per day, representing 15,000 loads of pollen, was obtained by a colony during the height of fruit bloom. This shows the great pollenizing value of strong colonies in fruit pollination.

In cooperation with the University of California pollens gathered by bees from 34 different plant sources were analyzed. A wide variation was found in protein and mineral content, as shown by the following summary: Protein, 7 to 35 percent; calcium, 0.3 to 1.18; magnesium, 0.06 to 0.35; phosphorus, 0.11 to 0.81; iron, 0.0006 to 0.0071; and potassium, 0.33 to 1.14 percent.

In studies made in cooperation with the Oregon Agricultural Experiment Station nectar from yellow sweetclover was found to contain more sugar than did that from white sweetclover. In the Imperial Valley of California the quantity of sugar in the nectar of alfalfa was greater for plants grown on dry soils than for those grown on wet soils. In the San Joaquin Valley the nectar secreted by the extrafloral nectaries of cotton was richer than that secreted by the floral nectaries.

The terms of the cooperative agreement under which the Bureau's bee culture sublaboratory was established at Madison, Wis., provide that the Bureau take over practically all the beekeeping work in the State. Operation of the Miller Memorial Beekeeping Library is thus included. With the cooperation of the University of Wisconsin, the collection has been classified by subjects. Cataloging will be done at a future date.

INVESTIGATIONS OF INSECTS AFFECTING MAN AND ANIMALS

SCREWWORMS AND BLOWFLIES

Several new insecticides which are superior to pine-tar oil for protecting animals against infestations by screwworms have been developed. One of these, diphenylamine, although not quite so effective as the others, now appears the most practical for general use because of its availability and relatively low cost, and information on the treatment of animals with this chemical has been released to the public. It has been found that the application of diphenylamine to wounds every third day will prevent them from becoming infested with screwworms and other fly larvae.

Laboratory tests with homologs of benzene as larvicides for the screwworm show that additions of 5 and 10 percent of thiophene and 10 percent of naphthalene to benzene enhance the toxicity of the latter. In undiluted form toluene appears slightly superior to benzene as a larvicide for the screwworm (*Cochliomyia americana* C. and P.), although the use of this material for destroying screwworms has been tried only under laboratory conditions.

Progress has been made in the study of the immunity of mammals to the screwworm. From a large number of tests it was determined that the number of screwworms constituting a maximum sublethal and a minimum lethal initial infestation in the average guinea pig was two and three, respectively, per hectogram of body weight. The maximum enhanced tolerance developed by guinea pigs to *Cochliomyia americana* larvae was found to be approximately 50 to 100 percent greater than that of unifested animals. It was found that this enhanced tolerance was the result of the initial infestation. The tolerance so developed was found to be systemic, but no substance deleterious to the larvae was demonstrated in guinea pigs from as many as four successive infestations. No enhanced tolerance was inherited by guinea pigs born of infested parents.

No immunity to *Cochliomyia americana* larvae was demonstrated by guinea pigs or sheep injected with six doses of vaccines composed of (1) mature tub-reared *C. americana* larvae, (2) mature sterile-cultured *C. americana* larvae, (3) pure cultures of *Proteus chandleri* Sand., an organism commonly associated with screwworms in wounds, (4) trypsin, (5) pepsin, and (6) the fluids in wounds infested with *C. americana* in guinea pigs, sheep, and goats.

Preliminary studies on treatments of sheep and goats with a number of organic chemicals dissolved in benzol indicate that these materials may be of considerable value in the prevention of fleece worm (*Phormia regina* (Meig.)) infestations in sheep and goats. The benzol acts as a larvicide, and upon evaporation leaves a deposit of the chemical on the wool and infested areas to serve as a protector against reinfestation.

In Texas it has been fairly definitely established over a three-season period by cage experiments and trapping surveys that *Cochliomyia americana* overwinters normally in restricted areas south of 30° N. During the coldest years the fly is eradicated from Texas, with the exception of a small area in the lower Rio Grande Valley. The overwintering area in Arizona is normally limited to the low valleys in the southern part of the State. In the Southeast during

a normally mild winter the pest is able to survive as far north as Valdosta, Ga., but during severely cold seasons the overwintering line is about 100 miles south of that locality.

HORN FLIES

The results obtained with an automatically operated fly trap during the second season of tests with this device continue to show its effectiveness in controlling horn flies on dairy and range cattle. On a large ranch near Fort Worth, Tex., the infestation of herds in pastures where these traps were in operation seldom exceeded 150 flies per head, whereas that of herds in circumjacent pastures where no traps were operated was 3,500 to 4,000 flies per animal.

Experiments were continued on the development of a method of controlling horn flies by feeding cattle certain insecticides which pass unabsorbed through the alimentary tract of the animal and render the feces unsuited for the development of horn fly larvae. Feeding phenothiazine at a minimum rate of 22 milligrams per kilogram of body weight was found effective in preventing horn fly development; however, this chemical appears unsuitable for this method of horn fly control since it causes a discoloration of the animal's milk, and continuous feeding or slight overdoses have a tendency to disturb the digestive processes or physical condition of the animal. Another chemical has been discovered which when administered in doses of 8.8 milligrams per kilogram of body weight is as effective as phenothiazine in preventing horn fly breeding and so far has not shown any ill effect on test animals.

CATTLE GRUBS

A practical method has been developed for treating range cattle for cattle grubs. It consists in applying to the backs of the infested animals a wash composed of 12 ounces of derris or cube powder, 4 ounces of soap, and 1 gallon of water. The cattle are run through chutes, and about one-third of a quart of the wash is distributed evenly over the back of each animal and then thoroughly rubbed in with the hands, the application requiring about 2 man-minutes per animal. In the more northern sections better results are obtained if the wash is warmed before the cattle are treated. In the southern parts of the country, where cattle do not carry a very heavy winter coat, about one-third less derris or cube will give almost as good results as the larger quantity.

EXTERNAL PARASITES OF SHEEP, GOATS, AND CATTLE

Continued research on methods of controlling various external insect parasites of animals has shown that a dip consisting of 100 pounds of wettable sulfur plus a wetting agent and 10 pounds of cube or derris powder containing 5 percent of rotenone in 1,000 gallons of water will kill all species of adult lice attacking sheep, goats, and cattle in the United States. This dip will also destroy the adults of the sheep tick, and tests so far indicate that it is effective against horse lice. In connection with the experiments with wettable sulfur, wetting agents have been developed that permit the use of sulfur in alkaline water without causing flocculation.

FLY SPRAYS

As a result of studies for developing more effective insect-killing and repellent sprays, a certain noninsecticidal vegetable oil has been found which, when mixed with pyrethrum sprays, greatly increases the toxicity of the insecticidal principles. The addition of 5 percent of this oil to the spray effectively prevents recovery of houseflies, even from light doses of pyrethrum. For household sprays the quantity of pyrethrum necessary to produce a satisfactory kill of flies can be cut in half when 10 percent of the oil is added, but the action of such a dilute spray is too slow to be satisfactory for use under more or less open conditions such as dairy barns. It was found that the oil increases the repellent action of pyrethrum sprays and enhances the efficacy of water emulsions of pyrethrum extract. A patent covering the free use of this material by the public has been applied for.

MOSQUITOES

Steady progress has been made in studying the habits and biology of the 23 species of mosquitoes in the Pacific Northwest. These numerous pest species have been grouped in 7 or 8 general associations so that practical information on mosquitoes and their control can be given the public. The classification of mosquito-breeding areas in this way as a result of surveys has been a distinct aid to mosquito-control agencies, since the mosquito problems vary greatly in the several physiogeographical areas of the Northwest. Two rather distinct and unique methods of control have been developed, (1) the destruction of the habitat of the floodwater species *Aedes vexans* (Meig.) and *A. aldrichi* D. and K. by clearing out the brush where the eggs have been deposited, and (2) control of the snow-water species *A. aboriginis* Dyar, *A. hexodontus* Dyar, *A. fitchii* F. and Y., and *A. communis* D. and G. by maintenance of water levels. There are certain limits in the application of these methods, but each is effective where it can be applied, and without undue injury to wildlife and fish. Definite information is obtained each year on the longevity and viability of the eggs of the first two species.

A comprehensive study of the effects of the Bonneville Dam on the mosquito population reveals that the impoundment of water by the dam has actually caused a decrease in the population of the important floodwater species above the dam from Bonneville to The Dalles, a distance of 50 miles.

Investigations of salt-marsh areas in Delaware and New Jersey, where extensive mosquito-control operations are under way, to determine the effect of ditching on marsh conditions, indicate (1) that changes in the flora and fauna of the marshes depend largely on the extent to which the water table is lowered, (2) that drastic lowering of the water table is not essential to effective mosquito control, and (3) that control measures should be adapted to meet individual conditions in each area.

In view of the importance of salt-marsh mosquitoes, a field laboratory was established at New Smyrna, Fla., to initiate detailed studies on their biology, habits, and control. It is expected that emphasis will be placed on developing more satisfactory control measures than

have been available heretofore and measures that will not affect the marshes as habitats of wildlife.

Intensive studies are under way to develop mosquito larvicides that are not only more effective but also nontoxic to birds, fishes, and plant life. Research thus far indicates that phenothiazine and a few other organic chemicals are promising in this respect.

CLEAR LAKE GNAT

Nonbiting midges of the genus *Chaoborus* which breed in enormous numbers in certain bodies of fresh water are a source of great annoyance to nearby residents and visitors to resorts in a number of localities in the United States. To determine methods of controlling them a field laboratory was established at Nice, Calif., on Clear Lake, where these insects are unusually abundant. Since relatively little is known of the biology of the gnats, considerable work has been necessary to determine their rather intricate life histories and their relationship to environmental factors. Preliminary studies have been made also to determine the value of various biological, chemical, and mechanical methods of destroying the gnats, but thus far nothing practical has been developed.

INSECT SECRETIONS

Extended research into the physiology of insect secretions has developed the fact that blowfly larvae cause the production of ammonia in the material upon which they are feeding. This ammonia production appears closely associated with the healing effects of surgical maggots and with the attractiveness of screwworm-infested wounds in animals. Up to the time of these investigations no definite evidence had been presented showing how the larvae produced ammonia. It has now been discovered that the maggots secrete the enzyme urease, and this, acting on the urea present in the tissues of larvae as well as of the wound, causes the formation of ammonium carbonate and ammonium bicarbonate. These materials have been found to have a stimulating effect on the healing of obstinate lesions.

TICKS AFFECTING MAN

Investigations have been continued on methods of controlling the American dog tick, which transmits Rocky Mountain spotted fever in the East. A dip or wash composed of derris (containing 3 percent of rotenone), neutral soap, and water has been found effective in preventing complete engorgement of female ticks on dogs. If dogs are treated twice a week with this material, no reproduction of the ticks occurs. Tests are under way to determine the feasibility of systematically dipping all dogs in a given area for elimination of the ticks. Experiments are also being carried on to determine whether the destruction of meadow mice, the principal hosts of the immature stages of the tick, will eradicate the ticks in limited areas.

HOUSEHOLD AND STORED-PRODUCT INSECTS

Investigation of a number of organic chemicals as possible mothproofing agents shows encouraging results with one or two com-

pounds, and further studies of these and new substances are being made.

In addition to handling a tremendous volume of correspondence relating to the control of household and stored-product pests, cooperation was extended to a number of commissaries of Federal establishments, such as the Procurement Division of the Treasury Department, and wholesale and retail grocers and confectioners, by giving them advice as to methods for ridding food commodities of insect infestation or protecting them from infestation, or by supervising the application of such methods.

Observations have been made on how some of the common packaged foods become infested. These studies indicate that when an insect-free commodity is thoroughly sealed in a clean cardboard carton, especially of the cylindrical type, it remains free from insect attack indefinitely, provided the seal or package is unbroken. Foods in rectangular cardboard cartons appear more likely to become infested than those in cylindrical ones, owing to the difficulty of making an impervious seal.

INSECT IDENTIFICATION

A total of 60,117 identifications were made and reported, in addition to approximately 4,000 that were required in connection with the white-fringed beetle survey conducted in the Southern States. About 70 percent of the determinations made were for the various research and regulatory units of this Bureau, including the Division of Foreign Plant Quarantines, and for other Federal organizations; about 15 percent were for agencies of the various States and the insular possessions; and the remainder were for individuals in the United States and for foreign institutions and individuals. Other service activities of the Division included assistance to numerous outside investigators on problems involving insect taxonomy, nomenclature, morphology, species distribution, and host relations; also the arrangement of 134 loans of insect material, comprising approximately 13,000 specimens selected from the reference collections by the specialists of the Division, and the review of 80 manuscripts for checking the accuracy of scientific names.

The extensive insect collections that are essential for the conduct of identification work have been maintained in good order and numerous subdivisions rearranged in accordance with recent revisions of the classification, thus facilitating the making of identifications in those groups. Numerous important additions, a total of more than 70,000 specimens, have been made to these collections during the year.

On an average, the 27 specialists of the Division could devote approximately only 20 percent of their time to research, owing to the large volume of service demands. Nevertheless, 52 manuscripts were completed and submitted for publication. These consisted in part of short papers prepared to supply authentic names required for use in biological and control studies conducted elsewhere in the Bureau or by outside agencies, but included also monographic papers, on some of which work had been in progress for several years. Among the latter are comprehensive taxonomic treatments of the following: *Chirothrips*, a genus of thrips; *Pantomorus*, the group containing the

white-fringed beetle; *Exenterus*, a genus of parasites of injurious sawflies; the moth family Oecophoridae; *Myzus*, an important genus of aphids; and *Osmia*, a large group of bees. Definite progress was also made on a considerable number of research projects that were not completed during the year, including a generic revision of the North American thrips, a study of the American thrips belonging to the genera *Thrips* and *Frankliniella*, revision of the weevil genus *Rhyncolus*, classification of the buprestid beetles making up the tribe Chrysobothrini, revisional studies of the bark beetles of the genera *Hylastes* and *Pseudohylesinus*, classification of the white grubs or larvae of the genus *Phyllophaga*, revision of the geometrid moths of the genus *Ellopia*, studies on the American Phycitinae, monograph of the blowflies of North America, revision of the fruitflies of the genus *Anastrepha*, revision of the North American wasps belonging to the genus *Trypoxylon*, studies in the classification of male ants, revision of the carpenter ants belonging to the genus *Camponotus*, generic revision of the family Cicadellidae (leafhoppers), a study of the true bugs making up the family Lygaeidae, review of the aphid genus *Kakimia*, revision of the grasshoppers of the genus *Orphulella*, a study of the order Protura, generic classification of the North American fleas, revisions of the scale insects belonging to the genera *Asterolecanium* and *Cerococcus*, and a study of the male genitalia of the Hymenoptera.

FOREIGN PARASITE INTRODUCTION

The foreign work of parasite introduction, centering largely at the field stations at St. Cloud, France, and Yokohama, Japan, has continued on the same series of crop pests as indicated last year, to which has been added the asparagus beetle and the pea moth in Europe and the white-fringed beetle in South America.

PARASITES OF CEREAL AND FORAGE INSECTS

Continued attention was given to securing parasites of the hessian fly, the vetch bruchid, and the European corn borer. Of hessian fly parasites, 2 shipments of *Trichacis remulus* (Walk.), totalling 518 adults, were made. A new and promising area for parasite collection was found in Morocco, where the infestation is heavier than in France and parasites are much more numerous. Stem infestation averaged about 67 percent during 1938 and parasitization ranged up to 76 percent, as contrasted with a very low percentage in France. The particular value of Moroccan parasites is the apparent readiness with which they attack the fall generation. Two new and promising species were secured from the Morocco material.

Vetch bruchid parasite material imported from France during the year consisted of 39,550 host eggs which had been exposed to *Triaspis thoracicus* (Curt.) and 2,776 adults of a new larval parasite, *Tetrastichus* sp. A total of 1,124 adults of *Triaspis* were shipped to North Carolina for early colonization during May and June.

Work on European corn borer parasites was restricted to the securing of *Phaeogenes nigridens* Wesm. from Italy. A total of 8,322 adults and 5,720 parasitized host pupae were forwarded during August.

During the period from September 1938 to April 1939 a survey was made of the white-fringed beetle in Argentina, Uruguay, and southern Brazil. In the first two countries the beetle was found generally, though not in sufficient abundance to cause injury to crops, but its range does not extend into the subtropical sections of southern Brazil. Damage by any species of *Pantomorus* (*Naupactus*) is limited very largely to relatively small patches in alfalfa fields, and the infestations do not persist from year to year. An extended search was made for natural enemies but no trace of these was found.

PARASITES OF COTTON INSECTS

The bulk of the pink bollworm parasite material imported from Japan and Chosen during the spring of 1938 was held in storage until August, at which time 72,000 cocoons of *Microbracon nigroruſum* Cushm. were forwarded to the Presidio, Tex., station of the Division of Cotton Insect Investigations. An additional quantity of 21,481 cocoons was held at the receiving station and the adults were forwarded. A total emergence of 59,500 was secured from the 2 lots.

PARASITES OF FOREST INSECTS

Activities in the field of forest-insect parasites consisted of an extended survey and study of the European spruce sawfly in northern Europe. The more extensive studies were made in Sweden, Finland, Lithuania, Latvia, and Estonia. The pest was found to be common, and abundant in restricted localities, throughout the range of spruce growth, this extending above the Arctic Circle in Sweden. Parasitization was found to be higher than in central Europe, ranging from 10 to 60 percent, the highest being in Estonia. This work is carried on in cooperation with the Canadian Department of Agriculture, which undertakes the large-scale collection and importation of material on the basis of information made available through the survey. From material imported in 1938 that Department shipped to the Bureau station a total of 12,968 adults of 2 species of *Exenterus*, as well as rearing stocks of *Microplectron* to State organizations.

PARASITES OF FRUIT INSECTS

Investigations in Japan and Chosen have been limited largely to a determination of the alternate hosts of the different parasite species attacking the oriental fruit moth which have been imported into the United States in past years. A number of the more important species have alternate hosts within which they pass the winter, and this habit may explain the difficulty in securing their permanent establishment in the United States. In February a shipment of 154 adults of *Phaeogenes haeussleri* Uch. and approximately 17,000 host cocoons containing larvae previously exposed to this parasite in the insectary was forwarded.

PARASITES OF TRUCK CROP INSECTS

Work upon lima bean pod borer parasites in France was continued on a reduced scale. Shipments totalling 12,223 *Phanerotoma planifrons* (Nees), 1,535 *Microbracon pectoralis* Wesm., 759 *M. piger* Wesm., and 1,082 of two minor species were made to California dur-

ing the latter part of 1938, and 483 adult *Chelonus* sp., with 1,800 parasitized host larvae, in the spring of 1939.

A new activity of the European station is the collection and shipment of *Meigenia floralis* Meig., a parasite of the asparagus beetle which is effective in France. The first shipment, consisting of 497 puparia and 4,800 parasitized larvae, was made in June.

One consignment of 153 puparia of the European earwig parasite *Rhacodineura antiqua* Fall. was forwarded to the Puyallup, Wash., station to serve as a rearing stock for domestic production.

A survey of the status of the pea moth was started in France during the year to determine if natural enemies play an important part in its control.

EFFECT OF CHEMICAL CONTROL METHODS ON POPULATION OF NATURAL ENEMIES

The major activities under this project have been concerned with the codling moth at Kearneysville, W. Va., the citrus scales and whiteflies at Orlando, Fla., and the citrus scales and red mites in southern California. The codling moth experiment which is carried on in cooperation with the Division of Fruit Insect Investigations and the West Virginia Agricultural Experiment Station has shown for the third year that the production of clean fruit is approximately equal in sprayed and unsprayed orchards. The factors responsible for this condition have not yet been fully determined, but predacious ants appear to be one of the most important.

In the case of the fungus diseases of scale insects and whiteflies in Florida, it has been found that the fungi are of very little value in control and that fungicides can be applied for the control of citrus diseases without regard to the effect upon the forms parasitic upon insects. An improved sampling technique has been developed which appreciably reduces the time and labor involved in experimental work on this problem.

The investigation on citrus insects and mites in California has shown, in the case of the black scale, that groves in certain sections may be left untreated without the development of a serious infestation, while if fumigation or spraying is started in such groves the population of natural enemies is reduced and the treatments must consequently be continued. The heavy red mite infestation during recent years in southern California is correlated with the more general adoption of oil sprays against the scale insects, and where such treatment can be avoided the injury by red mites is much reduced. A mechanical device was developed for use in sampling experimental plots, and this permits of 200 trees being adequately sampled in 3 or 4 days.

COOPERATIVE WORK WITH PUERTO RICO

The cooperative work with the Puerto Rico Agricultural Experiment Station of the Office of Experiment Stations has been continued, and the Division has provided directly, or through other Divisions of the Bureau, for the shipment to the island of five species of parasites of the lima bean pod borer from France, one pink bollworm parasite from Japan, and one parasite of the sugarcane borer from the United States.

Shipments to the United States from the Puerto Rico station comprised a rearing stock of the Sao Paulo strain of the Amazon fly (*Metagonistylum minense* Towns.), a promising parasite of the sugarcane borer, and the following beetle predators of the coconut scale: 120 *Cryptognatha nodiceps* Mshll., 600 *Pentilia castanea* Muls., and 225 *Pentilia* sp.

COOPERATION WITH FOREIGN ORGANIZATIONS

In addition to the cooperative work with the Canadian Department of Agriculture, already mentioned, colonies of parasites have been forwarded to foreign countries by this or other Divisions of the Bureau as listed in table 13.

TABLE 13.—*Shipments of parasites to foreign countries, fiscal year 1939*

Country	Host	Parasite
Canada	Citrus mealybug	*Pseudococcobius terryi* How.
Cuba	White peach scale	*Prospaltella berlesei* How.
Mexico	Citrus blackfly	*Eretmocerus sereus* Silv.
	Cottony cushion scale	*Rodolia cardinalis* Muls.
	Pink bollworm	*Microbracon nigrorufum* Cush.
	do	*Chelonus blackburni* Cam.
New Zealand	Cabbageworm	*Apanteles glomeratus* L.
Santo Domingo	Mealybugs	*Cryptolaemus montrouzieri* Muls.

CONTROL INVESTIGATIONS

TESTING INSECTICIDES

The work on testing insecticides was continued as in previous years except that many more tests were made with a larger number of insects. In testing organic compounds 10 materials were found which showed sufficient promise to warrant intensive study. All these when used as stomach insecticides caused high mortality to well-grown larvae of 3 or more species of insect pests. Some of these compounds may be of value in the commercial control of various insects.

In cooperation with the Division of Drug and Related Plants of the Bureau of Plant Industry approximately 600 preparations of rotenone-bearing plants and 72 preparations from plants producing pyrethrum, grown in the United States, were tested by biological assay to determine their insecticidal value. The results of this work are promising and indicate that it is possible by selection to obtain strains of plants with considerably higher insecticidal value.

The effect of the diet of certain insects on their susceptibility to poisons was investigated, and it was found to have a marked influence on the toxicity of some of the common insecticides, such as arsenicals. For example, larvae of the southern armyworm reared on pokeweed leaves were practically immune to dosages of lead arsenate which killed 95 percent of the individuals reared on young collards. Studies of household sprays on houseflies showed that flies temporarily paralyzed by the sprays were more resistant than the normally active flies. Four reports were prepared, mimeographed, and distributed making available the results of approximately 4,000 tests on 800 different materials made on about 21 species of insects. Preliminary results were obtained in tests with the more promising of these materials to determine their effect on the host plants.

FUMIGATION INVESTIGATIONS

The work on fumigation of nursery stock for the oriental fruit moth with methyl bromide was continued. Several of the Western States amended their quarantines so that treatment with this fumigant as found to be effective was approved as a condition for entry. One nursery fumigated and shipped 465 orders into these Western States during the year, a total of approximately 11,000 plants. It was shown in the investigational work during the 1938–39 season that a dosage of 2 pounds of methyl bromide for a period of 4 hours at 70° F. was effective in destroying all stages of this insect, and this modification of the usual treatment has been recommended, since there is less danger of injury to the plants with this lower dosage.

Fumigation with methyl bromide has been adopted quite generally throughout the quarantine-regulated area for treatment of produce in carlots to destroy the adult Japanese beetle. In continuing the investigational work, it was shown that it was possible to reduce the dosage of methyl bromide required at the higher temperatures and still kill all the Japanese beetles in carloads of produce. This will reduce the cost of the fumigant about 20 percent.

Investigations on the fumigation of nursery stock with methyl bromide for the larvae or immature stages of the Japanese beetle were carried on. They involved the fumigation and treatment of several thousand plants of 503 varieties and 187 genera to determine the effect of the treatment on the plants. It was found possible to obtain complete mortality of the Japanese beetle larvae in soil about the roots without injury to most types of nursery stock. The treatment is limited at present to soil masses 8 inches in least diameter and to bare-rooted nursery stock. Approximately 300,000 plants were treated for the Japanese beetle by this method.

A fumigant comprising a mixture of hydrocyanic acid and methyl bromide was developed. This is apparently much more toxic to the Japanese beetle adults than either one of the components in comparable concentrations.

Methods for the control of the white-fringed beetle (*Pantomorus leucoloma* (Boh.)) by fumigation of balled nursery stock with methyl bromide were developed, and about 10,000 plants were treated. This treatment is limited to nursery stock in soil masses not more than 3 inches in diameter. A method of fumigating potting soil with methyl bromide for this insect was also worked out, and treatment of soil about nursery stock with a solution of methyl bromide and alcohol in water was tested and proved effective.

Fumigation of sweetpotatoes with methyl bromide for the sweetpotato weevil was applied to about 2,000 bushels of seed sweetpotatoes with excellent results. Further work with sweetpotato plants showed that they can be freed readily from all stages of the sweetpotato weevil without injury by fumigation with methyl bromide.

Studies on the development of treatments for plants imported into this country were continued, and dosages of methyl bromide necessary to destroy all stages of mealybugs, red spiders, Cattleya leaf miners, active cockroaches, larvae of acorn weevils, bean pod borers, and a number of other insects were obtained. Treatment for *Maruca testulalis* (Geyer), a bean-pod borer, was worked out on a commercial

basis, and some 11,590 hampers of green lima beans and 97 crates of pigeonpeas were fumigated for this insect without damage to the commodity. A total of 9,575 cases of cipollini bulbs were also fumigated experimentally for larvae of *Exosoma lusitanica* (L.), with complete mortality of the insect and no injury to the bulbs. Comprehensive trials of 29 varieties of dormant deciduous woody perennials indicated that with one exception they were tolerant to methyl bromide at rather high dosages. Treatment of *Cattleya* orchids by fumigation with methyl bromide for the destruction of the Cattleya leaf miner indicates that this method might be used for this purpose, as orchids fumigated over a year ago are in excellent condition. Further work on this is necessary, however.

PHYSIOLOGY OF INSECTS

In the studies on the physiology of insects, work was continued on the formation and function of glycogen in the blood of insects. Glycogen is found in the eggs of the southern armyworm but is not found in the blood cells of the newly hatched larvae and was found rarely in first-instar larvae. It is commonly found in the later instars, being present in more cells the greater the instar. Starvation decreases and glucose injection increases the blood-cell glycogen. Both the blood-cell forms and the blood-cell glycogen were markedly affected by certain poisons, such as arsenicals, and only slightly or not at all by other poisons.

With arsenicals, however, the death of the insects seems to be due to a disintegration of the epithelial cells of the alimentary canal, and it is now known that preliminary phases of disintegration begin shortly after the poison reaches the tissues of the digestic tract and that the extent of the injury progresses from then until the lethal action is completed.

HEAT TREATMENT OF FRUIT

In connection with change in quarantine regulations which provided for the certification of Hawaiian-grown fruits and vegetables to the United States, subject to prescribed sterilization treatments at approved plants, investigational work was taken up to determine the tolerance of such commodities, particularly papayas, to the treatment required. This was necessary before a process could be developed which satisfied quarantine requirements and at the same time occasioned minimum injury to the fruit. The installation of equipment for applying the heat treatment and the testing of it were supervised. In cooperation with the Hawaiian Agricultural Experiment Station, studies were carried on in developing a satisfactory high-temperature treatment for papayas and the establishment of movements of this fruit on a commercial basis.

APPLICATION OF INSECTICIDES

The project for developing more effective methods of applying insecticides was advanced considerably this last year by the acquisition of an autogiro. This machine was equipped with an insecticide distributor of a design developed as a result of studies extending over several years. Initial tests of the aircraft and apparatus were inter-

rupted by severe damage to the autogiro during the New England hurricane of September 1938. Reconditioning of the aircraft and completion of tests in the spring of 1939 permitted actual field use of the equipment in June of the same year for treating an area near Greenfield, Mass., infested with the gypsy moth. Although the area treated presented unusual difficulties from the viewpoint of applying insecticides by means of a plane, the autogiro and the distributing apparatus operated successfully and without mechanical failure of any kind. The operations demonstrated that it was feasible to use rotary-winged aircraft over hilly, heavily wooded terrain, and that the method used in dispersing and distributing the insecticide was sound in principle.

INSECTICIDE INVESTIGATIONS

Efforts were continued to develop new and more effective insecticides. Many of the results were made available to the public by means of 58 scientific papers, comprising 1 technical bulletin, 10 articles in the Bureau's E series, 1 in the ET series, and 46 articles in technical and trade journals. Ten patents were issued to members of the Division, and the monthly review of United States patents relating to pest control was issued regularly and distributed to a large number of foreign and American entomologists.

CHEMICAL INVESTIGATIONS ON INSECTICIDAL PLANTS (TOBACCO, DERRIS, PYRETHRUM, ETC.) AND THEIR CONSTITUENTS

Investigations of pyrethrum narrowed down to an intensive study of the one still unknown feature of the nature of the two insecticidal pyrethrins it contains, namely, the exact structure of the side chain of the alcohol pyrethrolone. The latter has long been suspected to contain an allene grouping. During the year two compounds containing allene groupings were successfully synthesized, and bromine was found to react with them similarly to the way in which it does with pyrethrone. Final and direct confirmation will be sought by isolating one of the products of the bromine reaction and preparing from it a substituted caproic acid whose structure is known.

The work with rotenone-bearing plants was particularly characterized by a renewed intensive study of derris and cube resins, with special attention to deguelin because all available information indicates it to be the next most important compound. Deguelin is believed to exist in the resin in an optically active form, but no active crystalline material has ever been obtained, the deguelin heretofore available being the inactive form obtainable only after treatment of the resin with mild alkalies, which evidently racemizes it. The attempt to separate ordinary deguelin into its two optical components failed, but led to the discovery that it makes numerous complexes with various organic liquids, one of which, that formed with carbon tetrachloride, became the basis of a new method of estimating the quantity of deguelin present in a root or resin. High-vacuum distillation permitted the preparation of a solid substance containing over 80 percent of optically active deguelin, but even this could not be made to crystallize and yield the pure compound. The concentrated material has shown insecticidal effects of the same general intensity as those produced by rotenone.

The work with nicotine and tobacco took mostly an analytical turn. A new and delicate colorimetric method was devised which permits the determination of the nicotine on an individual sprayed apple, and is proving of great benefit in studying the various spray schedules that continue to show the value of the tank-mix nicotine-bentonite in controlling the codling moth. A variation of the method was developed which will permit at least a rough measurement of the nicotine content of a leaf selected from a growing tobacco plant, and is being used by the Bureau of Plant Industry in the study of the nicotine-producing power of hybrids and crosses of the tobacco plant.

The fruit of the Amur cork tree (*Phellodendron amurense*) having previously been found to contain an insecticidal principle, a detailed investigation of it was begun. Its stability toward alkali shows that it is quite different from either the pyrethrins or rotenone, and the absence of nitrogen proves that it is not an alkaloid.

CHEMICAL INVESTIGATIONS TO DEVELOP SYNTHETIC ORGANIC INSECTICIDES

The Division continued its search for synthetic organic insecticides, preparing several hundred compounds and submitting them to regular testing services supported by several other divisions of the Bureau. Those showing any marked insecticidal efficacy were made the subject of patent applications to guarantee their free use to the public; two such patents were secured.

Phenothiazine received further laboratory attention. Search for suitable stickers to use with it was continued, and the fact that it decomposes more rapidly in mixture with some accessory materials was noted; it was definitely recognized that fine subdivision of the material increases both its adherence to foliage and its toxicity to insects, and a study of its volatility was begun. A review of the literature concerning the rate of evaporation of slightly volatile substances led to the belief that phenothiazine may disappear by volatilization. The vapor pressure-versus-temperature curve of the compound has been determined, and actual evaporation studies are now under way.

Renewed attention was given to phenazine, for which no simple method of preparation has been known. Two new methods of synthesis have been devised, and its economical production by one or both of these is being further studied.

New compounds are regularly tested now against larvae of the screwworm fly, and during the year the toxicity of about 500 materials of known structure was studied. Hopes of finding enough structural relationship between active compounds to permit formulation of a working theory of toxic groups were not realized.

CHEMICAL INVESTIGATIONS OF SPRAY RESIDUES AND THEIR REMOVAL

The Yakima laboratory took part in its usual fruit-washing program in cooperation with the Bureau of Plant Industry. All lead residues were reduced below the new tolerance of 0.025 grain of lead per pound, loads as high as 0.190 grain per pound being reduced satisfactorily by even the single-process machine. All fluorine residues except one were cleaned well below the new tolerance of 0.020 grain of fluorine per pound. At Vincennes residues of arsenic, nicotine, and phenothiazine

were determined at intervals in all spray plots containing them to correlate the amount of residue with insecticidal potency. Distribution studies such as were formerly made with lead arsenate were made for nicotine-bentonite and phenothiazine, and much the same results obtained for the variances due to trees, parts of trees, and individual apples. An extensive study was made of residues from the use of calcium arsenate and of paris green on tomatoes. Immediately after the last application of undiluted calcium arsenate the tomatoes showed residues exceeding the tolerance, but these were easily removed by washing or wiping.

Articles were published on the removal of residues of phenothiazine and of nicotine-bentonite from apples. A very important digest and bibliography of the literature concerning insecticidal spray residues was issued during the year.

CHEMICAL INVESTIGATIONS TO DEVELOP INORGANIC INSECTICIDES

Articles were published concerning a method of making calcium arsenate of low solubility; a review of the uses of fluorine compounds as insecticides was issued; and a bibliography of all information on magnesium arsenate was published.

A study was begun of the use of sodium arsenite and white arsenic in the control of the Mormon cricket. Present practice calls for dusting the crickets with a mixture of sodium arsenite and diatomaceous earth, but there are some objections to this mixture. By a combination of laboratory and field work it was determined that the white, pure form of sodium arsenite now being used could be replaced by another commercially available gray, impure form with considerable saving in cost; that the poison as now produced is too coarse and the diluent too fine for the best results; and that white arsenic, at least in the forms now available, is not toxic enough to the crickets to be substituted for the sodium arsenite. The work will be continued to find out whether the sodium arsenite is being used at the optimum composition and concentration.

CHEMICAL INVESTIGATIONS OF FUMIGANTS FOR CONTROL OF INSECT PESTS

The work at Whittier, Calif., continued to deal with controlled dosage fumigation of lemons infested with the California red scale, in continuation of the effort to develop a set of experimental conditions so exactly reproducible that the effects due to differences in susceptibilities of insects, protective stupefaction, etc., can be more clearly demonstrated and measured. In addition, a study was made of the possibility of using methyl bromide against this scale. It was found that there was little difference in the susceptibility of the early gray adult insects from resistant and nonresistant strains, when compared either by means of various concentrations for a fixed exposure or at various exposures for a fixed concentration. The so-called resistant strain (i. e., to hydrocyanic acid) shows more resistance, however, when the oldest adults are tested. It seems also as if low temperature reduces the toxic effect of methyl bromide, which is contrary to the results with hydrocyanic acid. All the tests seem to indicate that methyl bromide is not very promising for use against

the California red scale in quarantine work, because of the high concentrations necessary to give a complete kill. Even at the rate of 7.5 pounds per 1,000 cubic feet there were occasional survivors in some stages. This work also gave an opportunity for studying the effect of methyl bromide on late pupae and unemerged adults of a parasite (*Comperiella bifasciata* Howard) of the yellow scale, and pupae of a predator (*Conwentzia hageni* Banks) of the citrus red mite.

CHEMICAL INVESTIGATIONS ON ACCESSORY MATERIALS FOR USE WITH INSECTICIDES

Studies were made of the effect, upon the wetting and spreading power of a commercial wetter, of the addition of calcium and magnesium salts, simulating its use in hard water. A relationship was demonstrated between the wetting power of spray solutions, as determined by the standard method used in the Division, and the initial retention of the solution by a sprayed fruit surface.

The intensive search for stickers for nicotine-peat and phenothiazine was brought practically to a close, without any very striking results. Of the nine stickers used with nicotine-peat, bentonite proved to be the only all-around satisfactory one when items of cost, availability, convenience, etc., were considered along with its actual performance. In the work with phenothiazine attention was paid not only to plain stickers, but also to antioxidants, in the belief that some of the lack of persistence is to be charged to decomposition rather than to mechanical loss. Many of the accessory materials hasten the decomposition, and the phytocidal action of any heavy deposits produced and maintained may offset considerably any insecticidal improvement. Short cellulose fibers from hemlock were given a trial, but were not particularly effective.

Much work was devoted to accessories for use with the tank-mix nicotine bentonite which is proving so successful against the codling moth. Its compatibility, as judged by maintenance of insoluble nicotine, with soaps, wetting agents, oils, copper fungicides, and lime-sulfur was studied, and it was found that any material with a marked alkaline reaction liberated the nicotine and hence may be judged incompatible. Variations in formula did not lead to any improvement over the already adopted formula for the nicotine bentonite.

A study was made of adjuncts for use with the standard Japanese beetle bait as a possible means of improving the attractiveness of the geraniol to last throughout the season. The value of antioxidants was explored, and it appears that basic substances are definitely barred, but that acids such as citric, acetic, and phthalic may have some value. The possibility of substituting thymol, safrol, phenol, and other similar materials for the eugenol commonly employed is also being studied.

The question of the suitability of diluents for use with powdered insecticides was brought to the fore by the investigation which was started in conjunction with Mormon cricket control. Numerous commercially available diluents were tested as to particle size and as to their tendency to separate from mixtures with sodium arsenite and white arsenic when blown from a dust gun, and indications obtained that there are probably more suitable ones than the diatomaceous earth now used.

Field trials in search of materials capable of aiding in the removal of lead arsenate from the grass on plots of ground to which it is applied for controlling Japanese beetle larvae demonstrated that a certain proprietary wetting agent when incorporated with the wash water normally used produced a decided benefit in this respect.

TESTS TO DETERMINE THE TOXICITY OF NEW INSECTICIDAL COMPOUNDS TO GOLDFISH

Efforts were continued to ascertain, by means of tests against goldfish, the correlation between toxicity of compounds and the chemical groupings they contain, so that the hunt for organic insecticides might be more intelligently guided. The work on the monosubstituted phenols was greatly advanced by a completion of the comparison of the isomeric chlorophenols, bromophenols, and iodophenols. The superiority of the iodine compounds over those containing chlorine or bromine and the general superiority of the para-substituted compound in each isomeric group was demonstrated. Work is now under way with the hydroxybenzoic acids.

All such work as this has been heretofore carried out at 27° C., but it has gradually become apparent that other temperatures might be more suitable for some tests; hence an investigation was begun of the temperature-mortality relationship in the case of goldfish exposed to the effects of rotenone and phenol, the two standard comparison materials now used. The importance of temperature control is readily appreciated in view of the fact that the survival time in solutions of either of these poisons is only about one-fourth as long at 27° as at 7°.

ANALYTICAL INVESTIGATIONS

The routine analytical work of the Division embraced, as usual, the analysis of several hundred samples of experimental insecticides being tested by other divisions of the Bureau and also nearly 500 samples of soil containing lead arsenate from the areas quarantined by the Division of Japanese Beetle Control.

As usual during the last several years, the collaborative work on the determination of minute amounts of arsenic in foods was conducted for the Association of Official Agricultural Chemists by the member of the Division who acts as referee on that subject. One of the three new methods mentioned in last year's report as having been developed by him was completely worked out and is under collaborative test this year; it is a titration method as delicate and as speedy as the Gutzeit method and decidedly more flexible and accurate. It appears certain to displace that time-honored procedure.

One of the several new procedures for determining residues of nicotine on sprayed fruit and foliage, namely, the colorimetric procedure using cyanogen bromide and α-naphthylamine, was also developed to a very satisfactory state, and, as it can be used in estimating the nicotine on a single apple, it is now making possible a detailed study of variability of nicotine residues such as was carried out for lead arsenate several years ago.

The colorimetric procedure developed in the Division previously for the determination of phenothiazine in spray residues was improved by adding a preliminary extraction with petroleum ether, in which the

decomposition products are insoluble, and with that modification the procedure was then shown to be applicable to the analysis of samples of insecticidal phenothiazine itself.

All the published color reactions for derris resin or for the rotenone or other constituents contained in it were given comparative trials so that their possibilities and limitations might be learned. The discovery that racemic deguelin forms with carbon tetrachloride a complex that is of low solubility led to the development of a new method for the determination of deguelin in roots and resins, and gives for the first time a convenient means of studying this, the second most important constituent of derris and cube.

Methods suitable for the determination of mercury, fluorine, arsenic, zinc, and copper in impregnated wood were published; the question of estimating the suitability of a particular bog iron ore, or limonite, as a corrective for arsenical damage to soil by determining the amount of iron oxide readily available for reaction with certain test solutions was investigated; a new apparatus was developed for the better testing of geraniol preparatory to its purchase as a means of baiting the Japanese beetle; and the importance of viscosity as a diagnostic property in studying decomposed baits was demonstrated. Improvements were made in the Rast and Segnor methods for determining molecular weights. Finally, a new apparatus was developed for the physical analysis of insecticides, comprising a very simple set-up for determining the average particle size of powdered materials. It is entirely self-contained and portable, occupies only about 1 square foot of space, and even contains an alignment chart which makes the calculations almost automatic. By its use a determination can be made in less than half an hour.

TRANSIT INSPECTION

Inspectors stationed at parcel post, express, and freight terminal points in 16 cities inspected 1,163,897 shipments for compliance with regulations of Federal domestic plant quarantine. Over 930,000 freight waybills were examined to determine certification status of shipments consigned thereunder. There were 3,719 violations intercepted, of which approximately 30 percent were of such nature that they were inspected, certified, and released by transit inspectors. One hundred and forty-eight apparent violations of intrastate quarantines relating to pests on account of which Federal quarantines have been established were reported to State plant-pest-control officials. One of the important phases of transit inspection is reporting to State officials shipments of nursery stock which have been consigned in apparent violation of State certification requirements. Over 550 of this type of shipments were so referred. During November and December the transit inspection force in New York and Boston was materially increased by the assignment of inspectors from another Bureau project so that thorough inspection could be made of the Christmas-season movement of decorative-plant material from the gypsy moth regulated area. This inspection resulted in the interception of approximately 300 shipments of material consigned in apparent violation of the gypsy moth and brown-tail moth quarantine.

Table 14 gives data pertaining to shipments intercepted at transit inspection points.

TABLE 14.—*Shipments of nursery stock and other articles intercepted in violation of Federal domestic plant quarantines at transit inspection points, fiscal year 1939*

Station	Shipments intercepted in apparent violation of quarantines relating to—								
	Black stem rust	Gypsy moth and brown-tail moth	Japanese beetle	Pink bollworm	Thurberia weevil	White pine blister rust	Mexican fruitworm	White-fringed beetle	Total
Atlanta		1	73	1			39		114
Boston		468	264						732
Chicago		35	206	5	1	6	6	1	260
Cincinnati		1	33	9		3	27	1	74
Dallas				9			25		34
Detroit		9	2						11
Indianapolis		1					1		2
Jacksonville		4	126					1	131
Kansas City		4	48	2		1	48		103
New York		383	571			10			964
Omaha		13	103			4		1	121
Philadelphia		64	160			1	17		242
Pittsburgh		14	469			5	23		511
Springfield, Mass		111	54						165
St. Louis		4	69				64	1	138
St. Paul	1	2	7			22	7		39
State of California		5	48	6	4	15			[1] 78
Total	1	1,119	2,233	32	5	67	257	5	[2] 3,719

[1] Interceptions reported by cooperating State inspectors at several inspection points.
[2] The total number of violations represents 3,628 shipments, 91 of which were in violation of 2 quarantines.

CONVICTIONS AND PENALTIES IMPOSED FOR VIOLATIONS OF THE PLANT QUARANTINE ACT

The following convictions and penalties imposed for violations of the Plant Quarantine Act were reported to the Bureau:

Avocado seed quarantine: One conviction, with a jail sentence of 90 days.

Gypsy moth and brown-tail moth quarantine: Two convictions, with fines aggregating $70.

Japanese beetle quarantine: Four convictions, with fines aggregating $65.

White pine blister rust quarantine: One conviction, with fine of $100.

Quarantines affecting Mexican plants and plant products: Fines aggregating $401.25 were imposed by customs officials on the Mexican border against 379 persons caught attempting to smuggle in prohibited plants and plant products from Mexico.

FOREIGN PLANT QUARANTINES

The Division of Foreign Plant Quarantines is engaged in the enforcement of quarantines and regulatory orders of the Department prohibiting or restricting the entry from foreign countries or the movement from Puerto Rico and Hawaii to the mainland of the United States of various plants and plant products, and restricting the movement of nursery stock into and out of the District of Colum-

bia. In addition, this Division is responsible for the maintenance of a service to inspect and certify plants and plant products to meet the sanitary requirements of foreign countries and for the enforcement of the provisions of the Insect Pest Act of 1905.

Plant-quarantine inspectors and collaborators are stationed at the more important ports of entry and at certain interior ports where foreign mail is distributed. They work in close cooperation with employees of the Treasury and Post Office Departments.

MARITIME-PORT INSPECTION

SHIP INSPECTION

Ships from foreign countries and also those from Hawaii and Puerto Rico and the coastwise ships which pass through the Panama Canal are inspected promptly on arrival for the presence of prohibited and restricted plant material. This inspection involves the examination of ships' stores and quarters, passengers' and crews' baggage, and cargo.

The inspection at ports in California, Florida, and Hawaii and at certain ports in Puerto Rico has been performed by State and Territorial officials serving as collaborators of the Bureau.

A record by ports of the ship inspection appears in table 14.

TABLE 14.—*Number of ships inspected, fiscal year 1939*

Port	From foreign ports												From Hawaii						From Puerto Rico						From United States ports via Panama Canal		
	Direct			Via United States ports			Via Hawaii			Via Puerto Rico			Direct			Via United States ports			Direct			Via United States ports					
	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material
Baltimore	629	628	255	913	769	376										38	2	0	17	17	3	39	33	2	238	94	1
Bellingham[1]	65	65	34	1	1	1							1	1	0										1	1	0
Boston	1,190	1,187	582	433	421	82										17	17	0	13	13	2				225	225	0
Brownsville	14	14	12	22	22	10																					
Brunswick[2]	3	3	3																								
Buffalo	6	5	5																								
Charleston	234	234	76	160	149	72													5	5	0	32	32	1	9	9	0
Chicago	22	22	20																								
Detroit	31	31	21																								
Eureka[3]	4	4	1	6	6	3							1	1	0	2	2	0							3	3	0
Galveston	397	396	233	502	501	296													9	9	1	4	4	0	5	5	0
Georgetown[4]	8	8	7																								
Guam	15	15	12	6	6	0							13	13	9												
Gulfport[5]	15	15	10	88	14	11													1	1	0	9	0	0			
Honolulu[3]	180	180	107	10	10	0																			87	87	0
Houston	548	545	415	476	453	279							1	1	1				8	8	4	2	2	0	40	40	0
Jacksonville[3]	304	304	63	112	103	29													37	37	1	5	4	0	7	7	0
Key West[3]	168	166	84	18	15	0																			1	1	0
Miami[3]	1,394	1,394	392	31	31	13				1	1	1							5	5	0				3	3	0
Mobile	300	300	113	350	333	160										6	6	0	50	50	9	45	44	2	62	62	0
New Orleans	1,159	1,159	680	489	488	317							8	8	5	9	9	0	20	20	4	67	67	1	53	53	0
Newport News	81	81	54	314	309	153										1	1	0	3	3	0	3	3	0	13	12	0
New York	3,783	3,727	2,359	852	707	429				78	78	68	17	17	1	31	25	1	141	139	47	17	8	0	307	209	4
Norfolk	355	355	172	701	693	311				1	1	0							11	11	3	43	43	5	92	92	0
Pensacola[3]	47	47	20	187	187	75													3	3	0	1	1	0			
Philadelphia	697	688	334	1,111	288	165				5	5	1				37	2	0	47	47	11	5	1	0	361	32	3
Port Arthur	426	426	354	338	337	143				1	1	1							13	13	2	4	4	0	20	20	0
Portland, Oreg	158	158	134	376	228	131							3	3	1	19	19	1							3	3	0
Port San Luis[3]	45	45	31										11	11	0										1	1	0
Puerto Rico (all ports)	937	931	316																						12	12	2
San Diego[3]	1,097	1,096	59	16	15	1							33	33	7										195	194	8

See footnotes at end of table.

TABLE 14.—*Number of ships inspected, fiscal year 1939*—Continued

Port	From foreign ports												From Hawaii						From Puerto Rico						From United States ports via Panama Canal		
	Direct			Via United States ports			Via Hawaii			Via Puerto Rico			Direct			Via United States ports			Direct			Via United States ports					
	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material	Arrived	Inspected	With prohibited material
San Francisco[3]	369	369	266	825	825	392	94	94	61	----	----	------	180	180	26	42	42	6	----	----	------	----	----	------	628	628	18
San Pedro[3]	1,486	1,484	918	536	528	213	62	62	39	----	----	------	86	86	23	65	65	15	----	----	------	1	1	0	827	826	93
Savannah	100	100	60	248	248	109	----	----	------	----	----	------	----	----	------	----	----	------	6	6	2	29	29	0	18	18	0
Seattle	1,311	1,188	304	322	317	201	1	1	0	----	----	------	1	1	0	9	9	1	----	----	------	----	----	------	1	1	0
Tampa[3]	294	294	107	287	283	115	----	----	------	----	----	------	----	----	------	----	----	------	16	16	1	1	1	0	2	1	0
Ventura[3]	----	----	------	----	----	------	----	----	------	----	----	------	3	3	0	----	----	------	----	----	------	----	----	------	----	----	------
West Palm Beach[3]	135	135	6	6	6	1	----	----	------	----	----	------	----	----	------	----	----	------	----	----	------	----	----	------	1	1	1
Wilmington[4]	37	24	22	7	7	4	----	----	------	----	----	------	----	----	------	----	----	------	1	1	0	----	----	------	----	----	------
Total	18,044	17,823	8,641	9,743	8,300	4,095	157	157	100	86	86	70	358	358	73	276	199	24	406	404	90	307	277	11	3,215	2,640	130

[1] Work handled by inspector stationed at Blaine.
[2] Work handled by inspector stationed at Savannah.
[3] Collaborators stationed at these ports.
[4] Work handled by inspectors stationed at Charleston.
[5] Work handled by inspectors stationed at Mobile.

NOTE.—The foreign-ship arrivals do not in all cases agree with customs figures. Ships which put in for bunkers may not be counted by customs. Ships entered at certain small subports and counted by customs are not included in this report.

CARGO INSPECTION

All importations of plants and plant products subject to plant-quarantine restrictions are inspected at the port of entry or at the port of first arrival. A summary of such importations grouped under four general subdivisions appears in table 15.

TABLE 15.—*Summary of importations of plants and plant products inspected, fiscal year 1939*

Port	Fruits and vegetables			Nursery stock and seeds			Bagging, cotton, cotton products			Bagasse, broomcorn, corn, rice fiber, etc.		
	Lots	Containers	Additional quantities	Lots	Containers	Additional quantities	Lots	Bales	Additional quantities	Lots	Bushels	Additional quantities
		Number			*Number*			*Number*			*Number*	
Baltimore	187		4,148,688 bunches	122	2,366	2,268 pounds	10	1,945		4	3,159	
Bellingham [1]				10	2,639							
Blaine	3	4	350 bunches	126	15,535	50 units, 85 pounds						
Boston	300	36,885	3,412,763 bunches, 316 pounds.	154	2,535	317 units, 10,842 pounds	870	64,641	319 packages	6	3,520	124 bales.
Boston, for export	78	17,987		1	40		14	2,653		4	3,305	
Brownsville	500	4,111	16,721 pounds, 48,311 bunches, 300 fruits.	5		9,771 units	277	22,997	7,487,259 pounds	1		2 bales.
Buffalo	51	5,544		46	76	10,822 units, 1,452 pounds	47	1,034		2	1,004	
Buffalo, for export				2	1	3 units	1	22				
Calexico	224	3,872					374	35,540	13,542,889 pounds			
Calexico, for export	1	1										
Charleston	164	2,807	1,960,527 bunches	13	994		25	3,086				
Chicago	11	12,078		7	644	7 pounds	1	8				
Del Rio	40	69	30 bunches									
Detroit	12	4,166		302	1,864	155 pounds	152	4,122		4	419	4 boxes.
Detroit, for export	1	651										
Douglas	9	48	52,000 pounds									
Eagle Pass	722	23,195	1,997 bunches							2		2 dozen.
El Paso	3,007	65,030	315,957 punches, 2,013,482 pounds.	3	8		47	861	1,004,667 pounds, 9 gallons.	(2)	56	
El Paso, for export	35	252	7 bunches, 11 fruits, 838 pounds.	1		9 pounds				16	298	
Galveston	162		3,517,668 bunches				67	16,395				
Galveston, for export							2	1,098				
Hidalgo	376	1,356		1	1		17	1,066		2	6	
Honolulu [3]	613	4,137		127	513	780 pounds				52		272 containers.
Honolulu, for export	1	17								1		9 containers.
Houston	1	9		1	10		178	52,290	7 packages			
Jacksonville [3]	214	103,843	2,548,789 bunches									
Key West [3]	406	13,177	450 bunches									
Laredo	2,904	328,088	1,915,090 bunches	36	99	3,797 units, 12 pounds						
Mercedes	1	1								1	1	
Miami [3]	1,297	591,693	329,431 bunches, 5,357 fruits.	13	5	1 unit, 1,092 pounds						
Miami, for export				2	1	4½ pounds						
Mobile	171		4,126,911 bunches	23	16,123		24	2,105				
Naco	1	1										
New Orleans	1,336	256,793	12,146,946 bunches, 8,610 pounds, 76 fruits.	20	30,255	40 pounds	111	22,961				

New Orleans, for export.	45	12,958					3	92				
Newport News				4	12							
New York	9,210	3,411,760	12,055,670 bunches, 10,648 fruits, 14 pounds.	1,565	74,223	22,441 pounds	1,317	195,067	181 packages, 20 pounds.	85	48,103	748 containers 40 pounds, 105 cars.
New York, for export	810	359,786		72	3,367		568	83,438	303 packages	19	697	2,614 containers.
Niagara Falls [4]	220	3,521		236	122	8,908 units, 260 pounds	166	3,249				
Niagara Falls, for export.							7	256				
Nogales	2,231	1,036,003	3,576 fruits, 500 bunches.	2		171 units				1		1 container.
Nogales, for export	24	186								1	1,518	
Norfolk	56		523,447 bunches	49	4,543		99	19,396				
Pensacola [3]	1		5,018 bunches									
Philadelphia	174	10,541	4,468,605 bunches	102	8,293	400 units, 1,643 pounds	77	5,831		14	11,497	868 bags, 182 bales.
Philadelphia, for export				2	51							
Port Huron [7]	8	2,220		36	54	639 units, 164 pounds	28	1,581				
Portland	6	30	27,811 bunches	13	295	113 pounds	5	507				
Presidio										2	10	
Providence [5]							28	5,623				
Puerto Rico	69	24,247	2 fruits	74	215	1,178 units, 1,691 pounds, 233 seeds.				156	320,234	
Puerto Rico, for export				1	1							
Roma	2	126										
St. Paul				1	1		22	221				
San Diego [3]	6	855	7,062 bunches	4	6	50 units, 5 pounds						
San Francisco [3]	1,204	16,034	1,712,090 bunches	328	4,815	3 units, 2,345 pounds	101	15,091	1 package	2		26 containers.
San Francisco, for export.	9	14		5	127		7	431	do			
San Luis [6]										2	115	
San Pedro [3]	339	21,787	2,058,859 bunches	84	2,257	17,492 pounds	129	12,584	1 package	1		25 pounds.
San Pedro, for export	2	4										
San Ysidro	37	523		8		1,264 units						
San Ysidro, for export	2	1,900										
Sault Ste. Marie [7]	11		1,819 bunches	2	1	1 unit						
Savannah	5		34,447 bunches	19	4,608		17	7,040				
Seattle	320	267,908	415,140 bunches	318	47,062	5,497 pounds	26	2,297				
Seattle, for export							1	55				
Tampa [3]	1,504	98,050	723,721 bunches, 979 fruits.									
Washington, D. C	2	2		1,688	3,013	10,119 pounds	2	2				
Total	29,125			5,628			4,820			378		
Total all lots, 39,951												

[1] Closed Sept. 10, 1938, and activities since that date handled by inspector stationed at Blaine.
[2] No port record kept of individual lots.
[3] Collaborators stationed at these ports.
[4] Work handled by inspector stationed at Buffalo.
[5] Work handled by inspector stationed at Boston.
[6] Work handled by inspector stationed at Calexico.
[7] Handled through customs.

In addition to the commodities listed in table 15, 1,030 lots of plant material were entered at Canadian border ports where no plant-quarantine inspectors are stationed, through the cooperation of the customs officers and of the Division of Foreign Pests Suppression of the Canadian Department of Agriculture. These importations consisted of 11 lots, containing 1,819 bunches of bananas; 376 lots, consisting of 10 612 bales of bagging, cotton, and cotton waste; 460 lots, totaling 1,709,751 bushels of corn; and 183 lots, consisting of 407 containers and 676 individual plants entering under regulation 15 of Quarantine No. 37.

At the Mexican border ports there were several thousand importations of fruits and vegetables in such small quantities that no entries were required by customs and no plant-quarantine record of them was kept, hence they do not appear in table 15. All these small importations were carefully inspected before being released, and their handling represented a great deal of work, especially at the larger ports. This type of importation has increased very greatly during the last few years.

Many of the ports have devoted considerable time to the inspection of packing materials used in connection with commodities not subject to plant-quarantine restriction. When prohibited packing material is discovered it must be treated or removed and destroyed under the supervision of a plant-quarantine inspector. Shipments of imported liquors have continued to arrive packed with straw jackets which have been contaminated with vetch plants bearing seeds infested with living bruchids. All jackets in which living bruchids were found had to be removed and destroyed or given to fumigation approved for imported vetch seed found to be infested with living bruchids.

DISINFECTION

Disinfection is required of certain commodities as a condition of entry and of other commodities when inspection reveals the presence of injurious insects or plant diseases. The following plant material was treated under the supervision of inspectors and collaborators of this Bureau:

Cotton	131,161 bales.
Cotton waste	17,653 bales, 40 bags.
Cotton linters	54,253 bales.
Cotton samples	13,687 packages.
Bagging	2,905 bales.
Rags	473 bales.
Broomcorn	190 bales.
Vetch	2,273 bags.
Rice fiber	580 bales.
Narcissus	3,877 cases, 37 bags, 80 baskets.
Tree seeds	457 containers, 10,553 pounds.
Miscellaneous plants	2,769 containers, 2,723 units.[1]
Chestnuts	2,624 cases, 221 barrels.
Cipollini	9,925 cases.
Lima beans	12,502 hampers.
Pigeonpeas	97 hampers.
Lily bulbs	438 cases.
Kudzu seed	9 bags, 2 cases.
Vicia faba	51 bags.

[1] Refers to plants, cuttings, bulbs, roots, or other propagating units concerned.

As a result of experiments conducted by the Division of Control Investigations the use of methyl bromide was approved for the fumigation of lima beans infested with the bean pod borer (*Maruca testulalis* (Geyer)) and of cipollini infested with *Exosoma lusitanica* (L.). Prior to this year infested lima beans were refused entry, and infested cipollini were either refused entry or given a hot-water treatment.

AIRPLANE INSPECTION

The number of airplanes from foreign countries continues to increase from year to year, and the possibility of introducing plant pests through this rapid means of transportation increases accordingly. During the year 4,969 airplanes from foreign countries were inspected. These inspections were made at the following 19 ports of entry: Douglas and Nogales, Ariz.; Calexico, Los Angeles, San Diego, and San Francisco, Calif.; Key West, Miami, Tampa, and West Palm Beach, Fla.; Agana, Guam; Honolulu, T. H.; Baltimore, Md.; New York, N. Y.; San Juan, P. R.; Brownsville, El Paso, and Laredo, Tex.; and Seattle, Wash.

Seven hundred and seventy-nine of the airplanes inspected were found to carry prohibited plant material, much of which came from places where it is known to be the host of injurious plant pests. Two thousand four hundred and forty-five interceptions of insects and plant diseases were made in connection with the airplane inspection. These represented specimens taken from plant material carried in baggage, cargo, and stores, and also insects which were being carried as stowaways on the planes. These interceptions are not only of interest as possible plant pests, but many of them represented different species of mosquitoes and other insects which might have decided importance, from the human-health standpoint.

While the majority of the interceptions represented forms which may be considered as having little economic importance, there were many interceptions which could be identified as to genus only, hence it is impossible to estimate their importance from a plant-pest standpoint. Interceptions of such well-known pests as fruitflies belonging to the genus *Anastrepha*, species of Aleyrodidae and *Pseudococcus*, the bean pod borer (*Maruca testulalis* (Geyer)), and several species of scale insects were included.

FOREIGN PARCEL-POST INSPECTION

Inspection of foreign parcel-post packages is carried on through the cooperation of customs and post-office officials. Under an arrangement which has been in effect many years, foreign mail packages found to contain plants or plant products are referred to inspectors of this Bureau for examination. Such packages arriving at ports of entry where no plant-quarantine inspectors are stationed are forwarded to the nearest port where inspection can be made.

A record by port of the number and disposition of foreign parcel-post packages inspected appears in table 16.

TABLE 16.—*Foreign parcel-post packages inspected, fiscal year 1939*

Port	Inspected	Refused entry (entire or in part)	Diverted to Washington	Released under permit
Atlanta [1]	77	9	40	0
Baltimore	1,250	26	114	64
Boston	7,093	75	1,499	99
Brownsville	1,061	1	0	0
Buffalo	1,550	25	177	31
Chicago	15,577	180	167	124
Detroit	5,569	89	106	120
Eagle Pass	485	0	0	0
El Paso [2]	542	26	23	8
Galveston	5	0	3	0
Guam	74	0	0	0
Honolulu [1]	2,448	293	0	191
Houston [3]	224	3	0	0
Jacksonville [1]	88	11	10	13
Laredo	1,048	22	31	3
Los Angeles [1 4]	4,965	71	13	31
Miami [1]	105	15	18	2
New Orleans	347	8	106	21
New York	335,114	416	4,670	342
Nogales [5]	351	11	5	2
Philadelphia	34,563	91	400	84
Portland [6]	1,047	19	0	32
Puerto Rico (all ports)	34	1	0	28
St. Paul	27,565	58	76	71
San Diego [1]	32	1	0	0
San Francisco [1]	5,627	94	4	790
Seattle	1,594	25	2	306
Tampa [1]	1	1	0	0
Washington	19,282	221	----------	3,929
Total	467,718	1,792	7,464	6,291

[1] Collaborators are stationed at these ports.
[2] 13 packages were diverted to San Francisco for disposition.
[3] 116 packages (cotton samples) were diverted to Brownsville for fumigation.
[4] 99 packages were diverted to San Francisco and 1 to Seattle for disposition.
[5] 12 packages were diverted to San Francisco for disposition.
[6] 7 packages were diverted to Seattle for disposition.

It has been the practice for a number of years to admit shamrocks through the mails provided they are free from soil. Large numbers are brought in in this manner each year, and they are included in table 16.

MEXICAN-BORDER SERVICE

At the beginning of the year certain of the newer types of boxcars, which are so constructed as to make it practically impossible for cottonseed to become concealed in them, were added to the list of cars which are exempted from fumigation provided that they are found, upon inspection, to be free from cottonseed. This added exemption, together with the decrease in the number of freight cars coming out of Mexico, was responsible for a decided decrease in the number of cars fumigated. All cars found contaminated with cottonseed were required to be cleaned before entry was permitted. The usual fee of $4 was charged for each car fumigated, and all fees collected were covered into the Treasury as miscellaneous receipts.

A summary of the railway-car inspection and fumigation is shown in table 17.

TABLE 17.—*Inspection and fumigation of railway cars crossing the border from Mexico, fiscal year 1939*

Port	Cars inspected	Cars with cottonseed	Cars entered	Cars fumigated	Fees collected
	Number	*Number*	*Number*	*Number*	*Dollars*
Brownsville	1,209	15	1,209	[1] 3	12
Douglas	2,291	11	2,291	34	136
Eagle Pass	2,073	317	2,073	576	2,200
El Paso	10,517	553	9,997	[2] 924	3,524
Laredo	11,861	1,404	10,834	1,651	7,200
Naco	903	10	903	7	28
Nogales	6,098	469	5,874	819	3,200
Presidio	560	18	560	10	40
Total	35,512	2,797	33,741	4,024	[3] 16,340

[1] Includes 2 trucks containing cotton machinery.
[2] Includes 5 cars and 1 truck not from Mexico.
[3] The apparent discrepancy in fees collected and the number of cars fumigated may be explained by the fact that it is customary for the railroads to purchase fumigation coupons in advance.

In addition to the freight cars listed in table 17, 4,480 pullman and passenger coaches entered and were inspected at the following ports: El Paso, 1,293; Laredo, 2,803; Nogales, 381; and Douglas, 3.

The improvement of highways in Mexico has resulted in a considerable increase in automobile traffic between the two countries. The records reveal that 4,019,169 vehicles and 340,487 pieces of personal baggage were examined, in cooperation with the customs service.

INSPECTION IN PUERTO RICO AND HAWAII

The enforcement of Quarantine No. 58, governing the movement of fresh fruits and vegetables from Puerto Rico to the mainland, is taken care of by plant-quarantine inspectors stationed on the island. Inspections are made in the orchards and fields, in packing houses, and on the docks, of such fruits and vegetables as are permitted to move to the mainland. During the year 2,812 shipments, consisting of 780 bunches of bananas, 474,813 crates of pineapples, and 24,477,500 pounds of other approved fruits and vegetables were certified for such movement.

While there has been a decided decrease in the amount of grapefruit shipped from the island to the mainland during the last few years, there has been an increase in other commodities. Exclusive of bananas and pineapples, the total quantity of other approved fruits and vegetables for the fiscal year 1938 amounted to 14,426,534 pounds. For the fiscal year 1939 these figures were increased to 24,477,500. The items responsible for most of this increase were cucumbers, plantains, tomatoes, and yams.

With the cooperation of post-office officials, parcel-post packages destined for points on the mainland were inspected at the four main post offices on the island. This arrangement makes it possible to intercept much prohibited plant material before it leaves the island and also reduces considerably the number of Puerto Rican mail packages requiring inspection on arrival in New York.

A total of 2,671 parcel-post packages were examined, and 160 were found to contain prohibited plant material and were returned to the sender.

The enforcement of foreign plant quarantines and regulations as they affect the entry of foreign plants and plant products into the island is under the general supervision of the inspector in charge of

the enforcement of the provisions of Quarantine No. 58. However, valuable assistance in this work is rendered by insular inspectors serving as collaborators.

In Hawaii the enforcement of foreign plant quarantines is handled wholly by insular inspectors serving as collaborators. The inspectors of this Bureau stationed in the Hawaiian Islands are engaged in the enforcement of Quarantine No. 13, which governs the movement of fresh fruits and vegetables to the mainland. Effective November 1, 1938, administrative instructions were issued authorizing the shipment of fruits and vegetables from Hawaii to the mainland subject to sterilization under supervision. Extensive experiments had demonstrated that the holding of fruits and vegetables at certain prescribed temperatures for certain periods would kill all stages of the Mediterranean fruitfly and the melonfly. This made it possible to ship host fruits and vegetables of these two insects, which prior to this date had been refused movement to the mainland. Supervising the approved treatments as outlined in B. E. P. Q. 481 has increased considerably the work of the plant-quarantine inspectors stationed in Hawaii.

During the year 2,721 shipments, consisting of 108,562 bunches of bananas, 105,010 crates of pineapples, 42,620 coconuts, and 2,269,485 pounds of other approved fruits and vegetables, were inspected and certified for movement to the mainland. Of these, 69,363 pounds were papayas and 28,117 were avocados which had been given the approved sterilization treatments in Hawaii under close supervision.

Inspections were made in the fields, in packing houses, and on the docks. The inspection of parcel-post packages destined for points on the mainland requires considerable time and effort. During the year 323,055 such packages were handled; 95,868 of these were opened and inspected, and 106 were found to contain prohibited plant material.

Since the inauguration of trans-Pacific air service it has been the practice not only to inspect the planes when they arrive from the Orient but also to inspect all planes, baggage, and express before the planes leave Honolulu for California. This procedure serves as an added precaution against the carrying of plant pests from Hawaii to the mainland and permits the prompt release of baggage and express upon arrival at the mainland. Under this arrangement 41 airplanes, 1,406 pieces of baggage, and 2,555 air-express packages were inspected. The airplanes arriving in Hawaii from foreign countries are included under the heading Airplane Inspection.

Other activities in Hawaii consisted in the inspection and sealing of 3,162 pieces of baggage and the inspection of 530 pieces of express leaving Hawaii by boat.

INSPECTION OF SPECIAL-PERMIT AND DEPARTMENTAL PLANT MATERIAL

Importations of propagating plant material are inspected at special ports of entry designated for that purpose. Most of such importations are inspected and treated at the inspection house in Washington, D. C., and it was the practice in past reports to include a table summarizing the inspection of plants and plant products in the District of Columbia. This table has now been discontinued, and Washington has been given the same status as other ports of entry in tables 14, 15, 19, and 20.

Recognition, however, should be given to the fact that the greater part of the importations handled in Washington, D. C., represented special-permit material and, as such, received very close inspection and frequently some sort of treatment as a condition of entry.

The enforcement of the regulations governing the movement of plant material into and out of the District of Columbia required the inspection of 1,164 shipments of incoming domestic material (consisting of 326,895 plants, cuttings, bulbs, etc., and 3,026 lots of seeds), 234 of which received some form of treatment for the elimination of pests; and 8,272 shipments of outgoing domestic material (consisting of 214,151 plants, cuttings, bulbs, etc., and 11,063 lots of seeds), 404 of which required treatment. In addition, 10,009 containers of domestic plant material were inspected at the post office and at railway and express stations. Twenty-one and one-half carloads of plants included in these figures are designated as 21½ containers.

INSPECTION OF PLANT-INTRODUCTION AND PROPAGATING GARDENS

Plant material which is being propagated at plant-introduction gardens maintained by the Bureau of Plant Industry is inspected at regular intervals for the presence of plant pests. Plant material distributed from the plant-introduction gardens at Coconut Grove, Fla., and Mandan, N. Dak., was inspected by State officials cooperating with this Bureau. The inspections at the plant-introduction garden at Chico, Calif., were handled jointly by an inspector of this Bureau and an entomologist from the California State Department of Agriculture. Material distributed from the District of Columbia, Maryland, and Savannah, Ga., was inspected by inspectors of the Bureau. A summary of these inspections appears in table 18.

TABLE 18.—*Plants, bud sticks, cuttings, tubers, roots, and shipments of seeds examined for distribution from plant-introduction and propagating gardens, fiscal year 1939*

Garden	Plants	Shipments of seeds	Bud sticks and cuttings	Roots and tubers
Bell, Md.	44,660	42	1,928	5,520
Chico, Calif.	5,314	61	3,912	35
Coconut Grove, Fla.	11,531	91	952	46
Savannah, Ga.	7,082	3	729	96
District of Columbia	9,186	10,687	3,545	20,133
Mandan, N. Dak.	253,390			
Total	331,163	10,884	11,066	25,830

INTERCEPTIONS OF PROHIBITED AND RESTRICTED PLANTS AND PLANT PRODUCTS

The inspection of ships, airplanes, vehicles, cargo, baggage, ship's stores and quarters, and foreign mail packages at the various maritime and border ports of entry resulted in the interception of large quantities of prohibited and restricted plant material. Much of this intercepted plant material was infested with insects or infected with plant diseases of considerable economic importance. In classifying the interceptions, those made at bridges and crossings at the Mexican and Canadian border ports have been considered as having been taken from baggage. A record of the number of interceptions of prohibited and restricted plant material appears in table 19.

TABLE 19.—*Number of interceptions of prohibited and restricted plants and plant products, fiscal year 1939*

Port	In baggage		In cargo		In mail		In quarters		In stores		Total	
	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Restricted	Prohibited	Prostricted	Prohibited	Restricted
Baltimore	6	2	57	0	25	6	78	0	168	3	334	11
Blaine	1,310	594					1	1	18	14	1,329	609
Boston	130	80	12	8	44	49	23	6	119	44	328	187
Brownsville	4,955	667			0	1					4,955	668
Brunswick [1]							6	0			6	0
Buffalo [2]	4	435	5	7	16	11					25	453
Calexico	3,484	102									3,484	102
Charleston	7	4					21	0	7	0	35	4
Chicago			35	12	101	58					136	70
Del Rio	699	173									699	173
Detroit	17	427	6	3	80	17					103	447
Douglas	441	84									441	84
Eagle Pass	1,311	237									1,311	237
El Paso	6,559	931	94	14	28	6					6,681	951
Galveston							444	3	102	0	546	3
Guam	7	0	5	0			2	0	7	0	21	0
Gulfport [3]	1	0					30	0	7	0	38	0
Hidalgo	3,287	428									3,287	428
Honolulu [4]	681	250	113	6	246	7			19	0	1,059	263
Houston	4	1	1	0	4	0	412	0	69	0	490	1
Jacksonville [4]					9	1	18	12	20	2	47	15
Key West [4]	92	67	1	0			20	27	10	0	123	94
Laredo	12,952	996	1	0	16	2					12,969	998
Los Angeles [4]	7	2	0	1	66	6					73	9
Mercedes	194	42									194	42
Miami [4]	1,437	1,076	29	3	15	0	339	597	113	4	1,933	1,680
Mobile	12	2	0	3			151	2	68	1	231	8
Naco	114	31									114	31
New Orleans	386	96	4	6	7	1	766	86	122	1	1,285	190
Newport News							15	14	12	1	27	15
New York	2,419	1,117	364	51	322	223	171	46	42	4	3,318	1,441
Nogales	3,524	760			4	9					3,528	769
Norfolk	5	4					85	10	31	1	121	15
Pensacola [4]							17	0	8	0	25	0
Philadelphia	13	12	28	3	89	12	68	17	48	3	246	47
Port Arthur	11	1	1	0			886	0	139	0	1,037	1
Port Huron [5]	2	325									2	325
Portland	2	0	3	0	8	12	12	0	24	3	49	15
Port San Luis [4]							1	0	1	0	2	0
Presidio	130	19	1	0							131	19
Puerto Rico (all ports)	65	71					2	3	2	0	69	74

Roma	110	25	1	0							111	25
St. Paul					42	16					42	16
San Diego [4]	2	6	1	0			49	9	51	9	103	24
San Francisco [4]	253	7	40	4	66	33	151	2	79	1	589	47
San Pedro [4]	440	27	21	0			90	5	176	2	727	34
San Ysidro	7,668	649									7,668	649
Sault Ste. Marie [5]	0	14									0	14
Savannah	3	0					67	0	6	0	76	0
Seattle	377	18	42	5	16	7	7	3	39	0	481	33
Tampa [4]	26	42	1	0			16	3	33	0	76	45
West Palm Beach [4]							4	1			4	1
Wilmington [6]									2	0	2	0
Total	53,147	9,824	866	126	1,204	477	3,952	847	1,542	93	60,711	11,367

[1] Work handled by inspector stationed at Savannah.
[2] Includes interceptions made at Niagara Falls.
[3] Work handled by inspectors stationed at Mobile.
[4] Collaborators stationed at these ports.
[5] Handled through customs.
[6] Work handled by inspector stationed at Charleston.

PESTS INTERCEPTED

The inspectors and collaborators of the Bureau collected from foreign plants and plant products insects belonging to 1,237 recognized species and others distributed among 983 genera and families, fungi and bacteria belonging to 321 recognized species, plant-parasitic nematodes belonging to 11 species, and numbers of interceptions caused by fungi, bacteria, viruses, or other agents that could be referred to family, genus, or other group only. Many of these interceptions were of economic importance or of scientific interest, or both.

A total of 57,561 interceptions of insects and plant diseases were made during the year. A summary of the interceptions appears in table 20.

TABLE 20.—*Number of interceptions of insects and plant diseases made during the fiscal year 1939*

Port	Cargo		Stores		Baggage		Quarters		Mail		Total	
	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases	Insects	Diseases
Baltimore	54	14	35	18	1	0	1	1	13	5	104	38
Bellingham [1]	2	3	3	0	0	0	0	0	0	0	5	3
Blaine	23	4	3	0	5	0	0	0	0	0	31	4
Boston	175	199	147	210	62	39	21	14	148	84	553	546
Brownsville	675	96	10	14	6,144	1,814	29	0	4	1	6,862	1,925
Buffalo	84	170	0	11	0	2	0	0	62	9	146	192
Calexico	0	2	0	0	172	12	0	0	0	0	172	14
Charleston	67	1	2	1	0	0	1	0	0	0	70	2
Chicago	56	12	1	0	0	0	0	0	39	3	96	15
Del Rio	0	0	0	0	395	0	0	0	0	0	395	0
Detroit	1	5	0	0	1	0	0	0	19	9	21	14
Douglas	2	1	0	0	418	3	0	0	0	0	420	4
Eagle Pass	103	0	0	0	257	0	0	0	0	0	360	0
El Paso	883	61	0	0	1,947	431	0	0	18	0	2,848	492
Galveston	283	19	20	82	0	0	15	1	0	0	318	102
Guam	1	0	0	1	0	0	996	0	0	0	997	1
Hidalgo	91	26	0	0	445	823	0	0	0	0	536	849
Honolulu	344	0	20	0	94	0	274	0	197	0	929	0
Houston	0	0	107	280	0	0	14	0	0	0	121	280
Jacksonville [2]	15	0	18	34	1	0	7	0	1	0	42	34
Key West [2]	1	0	6	1	35	5	0	0	0	0	42	6
Laredo	3,791	5	1	0	4,519	11	0	0	11	2	8,322	18
Los Angeles	2	0	0	0	0	0	1	0	12	2	15	2
Mercedes	0	0	0	0	212	8	0	0	0	0	212	8
Miami [2 3]	74	9	27	36	380	35	357	18	5	1	843	99
Mobile [4]	35	0	15	17	2	5	7	2	0	0	59	24
Naco	2	0	0	0	58	0	0	0	0	0	60	0
New Orleans	506	7	112	33	50	2	29	6	9	0	706	48
Newport News	4	0	2	9	0	0	0	0	0	0	6	9
New York	1,886	2,631	350	469	508	343	113	83	628	97	3,485	3,623
Nogales	2,792	645	0	0	1,793	131	0	0	5	0	4,590	776
Norfolk	81	17	25	35	4	0	0	2	0	0	110	54
Pensacola [2]	0	0	0	0	0	4	1	0	0	0	1	4
Philadelphia	79	269	69	997	14	18	13	67	48	115	223	1,466
Port Arthur	0	0	73	102	1	0	2	1	0	0	76	103
Portland	28	20	15	9	0	0	0	0	0	1	43	30
Presidio	0	0	0	0	31	2	0	0	0	0	31	2
Roma	0	0	0	0	6	7	0	0	0	0	6	7
St. Paul	0	0	0	0	0	0	0	0	17	8	17	8
San Diego [2]	12	0	28	5	5	0	5	1	6	0	56	6
San Francisco [2]	1,727	333	112	13	1,019	12	65	2	654	133	3,577	493
San Juan	25	6	1	0	30	4	2	2	6	1	64	13
San Pedro [2]	267	9	417	102	286	16	33	0	0	0	1,003	127
San Ysidro	8	3	0	0	840	3	0	0	0	0	848	6
Savannah	10	0	3	21	0	0	0	0	0	0	13	21
Seattle	434	201	61	45	37	17	21	11	57	29	610	303
Tampa [2]	2	7	9	11	12	9	2	0	1	0	26	27
Washington, D. C.	1,638	2,407	0	0	134	47	0	0	1,176	525	2,948	2,979
Total	16,263	7,182	1,692	2,556	19,918	3,803	2,009	211	3,136	1,025	43,018	14,777

[1] Closed Sept. 10, 1938.
[2] Collaborators stationed at these ports.
[3] Includes 157 airplane interceptions made by the Public Health Service.
[4] Includes interceptions made at Gulfport, Miss.

NOTE.—Inspectors stationed at Puerto Rico made 7 interceptions of insects during their field and packing-house inspection of fruits and vegetables for shipment to the mainland.

CERTIFICATION FOR EXPORT

During the year 9,412 certificates covering 3,591,165 containers of plants and plant products were issued to meet the sanitary requirements of foreign countries. This represents an increase of 204 in the number of certificates and a decrease of 426,642 in the number of containers certified, compared with the fiscal year 1938.

Export certificates were issued at 37 ports covering 65 different commodities which were exported to 83 foreign countries. Some of the more important commodities certified were the following: Apples, 2,170 shipments consisting of 1,362,106 boxes, 17,785 barrels, 56,484 baskets, and 181 packages; oranges, 1,137 shipments consisting of 566,267 boxes; pears, 823 shipments consisting of 500,639 boxes and 11,948 baskets; potatoes, 1,615 shipments consisting of 602,922 bags, 18,705 crates, 9,145 barrels, and 90 boxes.

Many of the shipments of apples and pears were certified under the cooperative arrangement with the Bureau of Agricultural Economics of the Department, whereby licensed inspectors of that Bureau located at shipping points make inspections and issue reports which are accepted by the plant-quarantine inspectors at the ports of export as a basis for issuing the required export certificate.

A brief summary of the export-certification work appears in table 21.

TABLE 21.—*Certification for export, by port, fiscal year 1939*

Port	Certificates issued	Total containers certified	Commodities certified	Foreign countries	Port	Certificates issued	Total containers certified	Commodities certified	Foreign countries
	Number	*Number*	*Number*	*Number*		*Number*	*Number*	*Number*	*Number*
Atlanta	1	29	1	1	New Orleans	74	19,004	9	7
Baltimore	15	34	3	4	Newport News	27	475	1	1
Boston	16	2,576	3	8	New York	5,021	1,283,756	33	63
Brownsville	61	35,487	3	1	Nogales	50	126	3	1
Buffalo	1	2	1	1	Norfolk	8	180	1	1
Calexico	91	51,090	5	1	Pensacola	1	150	1	1
Canal Zone	14	16	1	9	Philadelphia	9	14	3	4
Chicago	1 6	4	2	2	Port Arthur	4	3,700	1	4
Detroit	153	2,664	4	9	Portland	546	326,972	4	15
Eagle Pass	4	21	2	1	Presidio	1	918	1	1
El Paso	49	5,184	13	1	San Diego	3	3	1	1
Galveston	10	12	1	2	San Francisco	583	184,810	20	17
Hidalgo	21	989	3	1	San Juan	1	5	1	1
Honolulu	1	1	1	1	San Pedro	867	425,005	6	5
Houston	5	1,244	3	5	Seattle	1,480	1,149,363	14	15
Jacksonville	119	82,604	4	5	Tampa	3	4,396	2	2
Laredo	4	86	2	1	Washington	11	17	5	10
Los Angeles	121	8,565	9	3					
Mayaguez	22	44	2	12	Total	9,412	3,591,165	-------	-------
Mobile	9	1,619	4	2					

[1] Includes 1 duplicate certificate and 1 certificate for commodity not exported.

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